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# PESTICIDE RESEARCH PROJECTS

Funded by the Ministry
of the Environment
through the Ontario
Pesticides Advisory Committee

1987 - 1988

Ontario

The Ontario
Pesticides
Advisory Committee

Jim Bradley
Minister

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Pesticide research projects :
funded by the ministry of the
environment through the
Ontario pesticides advisory

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# PESTICIDE RESEARCH PROJECTS

FUNDED BY

THE MINISTRY OF THE ENVIRONMENT

THROUGH

THE ONTARIO PESTICIDES ADVISORY COMMITTEE

1987 - 1988

HAZARDOUS CONTAMINANTS
COORDINATION BRANCH
135 ST. CLAIR AVENUE WEST
TORONTO, ONTARIO M4V 1P5

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# PESTICIDE RESEARCH PROJECTS FUNDED BY THE MINISTRY OF THE ENVIRONMENT THROUGH THE ONTARIO PESTICIDES ADVISORY COMMITTEE, 1987-88

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## EXECUTIVE SUMMARY

1. In 1987-88, the Ontario Pesticides Advisory Committee continued a program, begun in 1973, of funding research on pesticides. The objectives of the program are :

(a) To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.

(b) To determine potential environmental hazards with pesticides currently in use.

(c) To reduce pesticide input into the environment.

2. The research budget was $ 400,000.

3. Sixty-one research proposals totalling $ 1,016,310 were received.

4. Thirty-one proposals were funded with a total value of $ 399,850. Awards averaged $ 12,900 and ranged from $ 4,100 to $ 45,000. An additional project was transferred to the Ministry of the Environment and funded through their Research Advisory Committee's research budget.

5. Eleven grants totalling $ 104,750 were allocated to studies on the development of alternative pesticides and investigations into biocontrol.

6. Nine grants totalling $ 162,600 were allocated to studies on the behaviour and fate of pesticides in the environment and on the potential environmental hazards to non-target organisms.

7. Eleven grants totalling $ 132,500 were allocated for studies aimed at reducing pesticide input into the environment, while still achieving effective pest control.

8. The Pesticides Advisory Committee is very satisfied with the research progress in 1987-88. It recognizes that, with the funds available, the program can be expected to act as a catalyst in stimulating support by other interested agencies for urgently required research in the broad areas indicated in the Committee's guidelines.

9. The Pesticides Advisory Committee recommends that:

a) The Ministry of the Environment continue to support research programs directed toward the development of pest control programs which will not pose any serious environemental hazard.

b) The Pesticides Advisory Committee continue to supervise the program following the guidelines that have been developed.

## I. OBJECTIVES

The Ministry of the Environment first allocated funds to the Ontario Pesticides Advisory Committee (OPAC) to sponsor pesticide-related research in 1973. Terms of Reference developed by OPAC to govern the awarding of research grants are based on three general objectives:

1) To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.

2) To determine potential environmental hazards with pesticides currently in use.

3) To reduce pesticide input into the environment.

An "Application for Research Grant", which invites research proposals in several specific areas relating to the program objectives is reviewed and revised annually by OPAC in consultation with the Ministry of Environment Research Advisory Committee. In 1987-88, research proposals were invited in ten specific areas with two areas of emphasis relating to the three research objectives (Appendix I).

## II. SELECTION PROCEDURES

Notices inviting applications for research support were widely distributed in November, 1986 through January, 1987 to researchers and administrators in Ontario universities, industry, government, and other organizations, with deadline of receipt of applications being January 23, 1987.

During the first two weeks in February, members of the Research Subcommittee and selected reviewers appraised the submissions and ranked the proposals in three categories: fund, not fund, reconsider with changes. The reviewers were chosen for their broad knowledge of pesticides and expertise in pest control.

Criteria used in judging the applications included:
i) applicability to research objectives,
ii) scientific quality of the research proposal, and
iii) ability of the applicant(s) to carry out the research as proposed.

Six applications were received later in the year and were similarly considered.

Recommendations prepared by the Research Subcommittee were reviewed by the entire Pesticides Advisory Committee February 23rd. OPAC recommendations were then forwarded to the Ministry of Environment's Research Advisory Committee for confirmation and funding. Funds were made available to most grant recipients by mid April.

## III. PROJECTS SUPPORTED

The OPAC research budget in 1987-88 was $ 400,000.

Sixty-one research proposals totalling $ 1,016,310 were received. Most (48) were from universities/colleges (Guelph, Queen's, Sault College of Applied Arts and Technology, Ridgetown College of Agricultural Technology, Toronto, Trent, Western, Waterloo, and York). The remaining applications were from industry or other organizations.

Thirty-one proposals were accepted (Appendix II). Awards averaged $ 12,900 (range $ 4,100 to $ 45,000). Disbursement of research funds by organization is summarized below:

| Organization | No. of Grants | $ Total of Grants |
|---|---|---|
| University of Guelph | 16 | 210,350 |
| Sault College of Applied Technology | 4 | 38,500 |
| Queen's | 2 | 13,500 |
| University of Western Ontario | 2 | 20,700 |
| Ridgetown College of Agricultural Technology | 2 | 16,300 |
| Trent University | 1 | 45,000 |
| University of Toronto | 1 | 17,000 |
| University of Waterloo | 1 | 15,000 |
| Other | 2 | 23,500 |
| TOTAL | 31 | 399,850 |

Results obtained in the various studies are summarized in Appendix III.

Eleven grants (Appendix III #s 1, 3, 4, 5, 9, 10, 15, 17, 19, 22, 31) totalling $ 104,750 were awarded for studies on the development of alternative pesticides and investigations into organisms which show promise for biological control.

Nine grants (Appendix III #s 6, 11, 12, 13, 16, 18, 21, 28, 29) totalling $ 162,600 were allocated for studies to determine the potential environmental hazards with pesticides currently in use.

Eleven grants (Appendix III #s 2, 7, 8, 14, 20, 23, 24, 25, 26, 27, 30) totalling $ 132,500 were allocated for studies aimed at reducing pesticide input into the environment, while still achieving effective pest control.

## IV. ACCOUNTABILITY

Direction and progress of the research were monitored by OPAC in several ways. Initially, some applicants were asked to modify their proposals to better meet the research guidelines. In July, 1987 as part of the OPAC Research Subcommittee Field Trip, some of the researchers receiving financial support were included on the agenda, thus giving OPAC members an opportunity to become acquainted with the cooperating scientists and research in progress. Informal contacts with OPAC members and grant recipients were established and maintained throughout the year.

In January, 1988, OPAC sponsored a two day Seminar where grant recipients presented the results of their research. This meeting was attended by OPAC members and more than 90 colleagues, peers, and guests.

In addition, the recipients were asked to provide OPAC with a summary of progress and, where necessary, a comprehensive project report (Appendix III).

Research reports, manuals, theses etc. published in 1987-88 relating to OPAC sponsored research are listed in Appendix IV.

## V. RECOMMENDATIONS

The Pesticides Advisory Committee is pleased with research progress made in 1987-88. The Committee recognizes that with the funds available, the program can be expected to act only as a catalyst in stimulating support by other interested agencies for urgently required research in the broad areas indicated in the Committee's guidelines. The Committee recommends:

1) The Ministry of the Environment continue to support this very productive research program directed toward development of pest control programs which will not pose any serious environmental hazard.

2) The Ontario Pesticides Advisory Committee continue to supervise this program following the guidelines which have been developed. With its broad expertise, strong scientific background and close liaison with the scientific community, OPAC is in the unique position of being able to define research priorities and to ensure that excellent value is received for money spent.

## APPENDIX I: ANNOUNCEMENT INVITING APPLICATIONS FOR RESEARCH SUPPORT FROM THE ONTARIO PESTICIDES ADVISORY COMMITTEE

**November 1986**

The Ontario Ministry of the Environment through the Pesticides Advisory Committee again has limited funding available for the fiscal year 1987-88 to support research relating to innovation and improvement of the management of pesticides in Ontario. The priority areas of interest are:

**Determining environmental fate of pesticides and impact on the environment and human health;**

and

**Development of new or improved methods of pest control through identification of alternatives to chemicals deemed to be hazardous or to traditional chemical pesticides.**

Preference will be given to proposals yielding results in a relatively short time, with funds being committed on a yearly basis. Research should be in the context of normal use patterns.

While there is no intention of constraining the scope of applications which may be submitted for 1987-88, the following list is presented to indicate some of the areas of current interest which may be useful in preparing proposals.

**Determining environmental fate and impact of pesticides on the environment and environmental health.**

1. Persistence, degradation, biological and health significance of pesticide residues in soil, air, water, and food.

2. Potential for pesticide contamination of ground and surface waters and methods for minimizing these hazards.

3. Safe re-entry procedures following pesticide treatment in buildings and determination of exposure of agricultural, horticultural and forestry workers, licenced applicators, and the public to various types of pesticide applications.

4. Assessment of the effectiveness of protective equipment and the

development of improved protective equipment.

5. Criteria for the development of buffer zones for application of pesticides.

6. Investigation of pesticides in the urban environment with respect to use patterns, efficacy, application methods and impacts on human health and environment.

**Developing new or improved methods of pest control.**

7. Development of more efficient, effective and cost-effective techniques of pesticide application.

8. Development of pest monitoring techniques or integrated or non-chemical methods of pest control.

9. Economics of pest control, including determination of economic thresholds and estimates of crop losses.

10. Identification of efficient effective and environmentally acceptable pesticides or pest control methods for use in structures or for the protection of stored products.

## APPLICATION PROCEDURES

Research proposals should be submitted to:

Dr. K. A. Howard
Chairman
Pesticides Advisory Committee
Ministry of the Environment
Suite 100, 135 St. Clair Avenue West
Toronto, Ontario M4V 1P5

Applications should be received by January 23, 1987, and should include the following:

1. Title of project.
2. Name, address and affiliation of applicant(s).
3. Summary of proposal

4. Discussion of problem.
5. Statement of objective(s).
6. Plan for program.
7. Facilities available.
8. Budget - categorize costs as: Personnel - full/time and part/time, Equipment, Supplies, Overhead Costs, Other.
9. Curriculum vitae on principal investigator(s), (if not already on file with OPAC).

Successful applicants are expected to present a written abstract prior to, and an oral progress report at the Committee's annual research seminar held in January, 1988. A final report acceptable to the Pesticides Advisory Committee will be required on termination of the project. A financial report may be required at the discretion of the Advisory Committee.

APPENDIX II: RESEARCH PROJECTS SUPPORTED BY THE ONTARIO PESTICIDES ADVISORY COMMITTEE, 1987-88

| NO. | APPLICANT(S) | AFFILIATION | PROJECT TITLE | $ AMOUNT GRANTED |
|---|---|---|---|---|
| 1. | BARRON,G.L.<br>Townsend, J.L.<br>Meskine, D. | U. of Guelph | Biological control of *Meloidogoyne hapla* on alfalfa and tomato using nematode destroying fungi. | 10,400 |
| 2. | BROWN, R.H.<br>Huffman, L. | Ridgetown College<br>OMAF | Assessment of reduced amounts of herbicides applied more frequently to orchard crops. | 5,000 |
| 3. | BOLAND, G.L.<br>Inglis, G.D. | U. of Guelph | Biological control of *Sclerotinia sclerotiorum* in white bean. | 14,500 |
| 4. | BURPEE, L.L.<br>Riddle, G.E. | U. of Guelph | Biological control of dandelions in turfgrass swards. | 7,000 |
| 5. | BURPEE, L.L.<br>Lawton, M.B.<br>Goulty, L.G. | U. of Guelph | Development of an effective dissemination procedure for the snow-mold-control agent *Typhula phacorrhiza*. | 10,000 |
| 6. | BUTTLE, J.M.<br>Harris, B.J. | Trent U. | Metolachlor loadings to surface water: the role of watershed conditions and application techniques. | 45,000 |
| 7. | EDGINGTON, L.V.<br>Banks, E. | U. of Guelph | Potential of flooding for controlling hematodes and fungi in organic soil. | 15,000 |

| NO. | APPLICANT(S) | AFFILIATION | PROJECT TITLE | $ AMOUNT GRANTED |
|---|---|---|---|---|
| 8. | ELLIS, C.R.<br>Stoewen, J.F. | U. of Guelph | Winter survival and economic thresholds for corn rootworms in field corn. | 18,600 |
| 9. | FAULKNER, P.<br>Allen, W.R.<br>Trimble, R.M. | Queen's University<br>CDA, Vineland<br>CDA, Vineland | Development of a monoclonal antibody probe for eggs and larvae of the parasite *Pholetesor ornigis* Weed (Hymenopter:Braconidae). | 8,500 |
| 10. | FITZ-JAMES, P.<br>Atkinson, M.<br>Byrnes, J. | U. of Western Ontario | Yield studies of a putative corn rootworm pathogen. | 6,000 |
| 11. | FRANK, R.<br>Braun, H.E.<br>Stanek, J.<br>Ritcey, G. | OMAF<br>"<br>"<br>U. of Guelph | Studies on the disappearance of pyrazophos, oxyfluorfen and oxadiazon. | 5,500 |
| 12. | FRANKENHUSEN, K. van<br>Nystrom, C. | Sault College of Applied Arts and Technology | Effects of post spray weather on persistence of *Bacillus thuringiensis* on coniferous foliage. | 11,900 |
| 13. | GAYNOR, J.D. | Harrow | Herbicide export from Brookston clay loam soil under conventional and conservation tillage systems. | 18,000 |
| 14. | HALL, R. | U. of Guelph | Improved efficiency of chemical control of white mold in snap bean. | 10,000 |

| NO. | APPLICANT(S) | AFFILIATION | PROJECT TITLE | $ AMOUNT GRANTED |
|---|---|---|---|---|
| 15. | HARMSEN, R.<br>Clements, D. | Queen's University | Development of an integrated pest management module for the forecasting and control of phytophagous mites in apple orchards. | 5,000 |
| 16. | KAUSHIK, N.K.<br>Sibley, P. | U. of Guelph | Toxicity of microencapsulated permethrin to selected aquatic invertebrates and methods for identifying microcapsules in aquatic habitats. | 13,500 |
| 17. | KEVAN, P.G.<br>Eiskowitch, D.<br>LaChance, M.A. | U. of Guelph | Yeasts and milkweeds: using yeasts to supress fruit and seed-set in milkweeds. | 7,600 |
| 18. | KINGSBURY, P.<br>Barber, K. | Sault College of Applied Arts and Technology | Developing an implementation protocol for fruit-set of the forest wildflower *Polygonatum pubescens* in an insecticde impact monitoring program. | 12,500 |
| 19. | LAING, J.E.<br>Wang, T. | U. of Guelph | Establishment of the parasitoid *Holcothorax testaceipes* in Canada and assessment of its impact on *Phyllonorycter blancardella.* | 7,850 |
| 20. | MAKEY, S.R.<br>Hastie, G.M.<br>Pitblado, R.E. | H.J. Heinz Co.<br>"<br>Ridgetown College of Agricultural Technology | Development of a weather-timed fungicide spray program in field tomatoes. | 11,300 |

| NO. | APPLICANT(S) | AFFILIATION | PROJECT TITLE | $ AMOUNT GRANTED |
|---|---|---|---|---|
| 21. | MORRISON, A.B.<br>Mbogo, E.W.<br>Kakuda, Y. | U. of Guelph | Effect of processing on cypermethrin residues in green beans and broccoli. | 8,200 |
| 22. | McLEOD, D.G.R.<br>Tomlin, A.D.<br>Tolman, J.H.<br>Whistlecraft, J.W. | U. of Western Ontario | Assessment of the potential of *Aleochara bilineata* for the control of root maggots in the home garden. | 14,700 |
| 23. | NEALIS, V.G. | Sault College of Applied Arts and Technology | Parasitoids and pest management of the jack pine budworm. | 10,000 |
| 24. | SANDERS, C.J. | Sault College of Applied Arts and Technology | Development of sex phermone traps for monitoring jack-pine budworm. | 4,100 |
| 25. | SEARS, M.K. | U. of Guelph | Impact of potato leafhoppers on potatoes in southern Ontario. | 18,000 |
| 26. | SMITH, S.M. | U. of Waterloo | A barrier-trapping technique for the control of *Glischrochilus quadrisignatus* (Coleoptera: Nitidulidae) and assessment of the dispersal behaviour of the beetle between raspberry, corn and tomato fields. | 15,000 |

| NO. | APPLICANT(S) | AFFILIATION | PROJECT TITLE | $ AMOUNT GRANTED |
|---|---|---|---|---|
| 27. | SOUZA MACHADO, V.<br>Ali, A. | U. of Guelph | Substitute herbicides for allidochlor in onions. | 8,000 |
| 28. | STEPHENSON, G.R.<br>Bowhey, C.S.<br>Ekler,Z. | U. of Guelph | Persistence, mobility and activity of sulphonyl urea herbicides in the Ontario soil. | 31,000 |
| 29. | STOKES,P.M.<br>Whelpdale, D. | U. of Toronto | Pesticide residues in lichens from the northern Great Lakes basin: an assessment of a biomonitor. | 15,000 |
| 30. | SURGEONER, G.A. | U. of Guelph | Management of house flies by sanitation - impact of resistance. | 17,500 |
| 31. | SUTTON, J.C. | U. of Guelph | Biological control of strawberry and raspberry diseases. | 13,200 |

## APPENDIX III: SUMMARY PROGRESS REPORTS, 1987-88

### 1. TOWNSEND, J.L., BARRON, G.L.* and MESKINE, D. - Biological control of Meloidogyne hapla on alfalfa and tomato using nematode destroying fungi.

The northern root-knot nematode, Meloidogyne hapla, is a common plant parasite in agricultural soils in Ontario. Microplot studies have shown that this nematode can significantly reduce yields of alfalfa and tomato. Economically, however, it is not always practical to fumigate soils with pesticides for crops such as alfalfa. Application of nematode-destroying fungi to seed, or to roots of transplants, could be alternative methods for root-knot control.

The seeds of tomatoes and alfalfa or the root of transplant seedlings were coated with the nematode-destroying fungi Arthrobotrys oligospora, Arthrobotrys flagrans, and Meria coniospora and planted in plots filled with silt loam infested with Meloidogyne hapla.

In the studies with alfalfa, Meria coniospora reduced the galls on the roots of three-week-old seedings by up to 60% but the numbers of second stage juveniles in soil was not reduced. With tomatoes, there were 49% fewer galls/g root at 28 days and 41% fewer galls/g root at 56 days with M. coniospora than the untreated control. In root treatment of tomato transplants with Meria coniospora, galls were reduced by 46% relative to the control at 28 days. There was no improvement, however, in the weight of tops or root with fungal treatments. In the fumigated soil, however, after 28 days, top and root growth was significantly greater than that of the controls.

### 2. BROWN, R.H. - Assessment of reduced amounts of herbicides applied more frequently to orchard crops.

Herbicide treatments were applied to established apple, (variety: Empire) sour cherry, (variety: Montmorency) and peach (HW240) trees at Delhaven Orchards, Blenheim owned by Hector Delanghe. There were two objectives:
(1) to determine if lower recommended rates of registered herbicides or combinations of herbicides applied twice in a season would result in longer and better weed control compared with a single application; and
(2) to test some new unregistered herbicides to determine their efficacy.

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* Underlining designates Principal Investigator

Weed species included Canada thistle, annual and perennial sowthistle, quackgrass, bindweed, pigweed, lamb's quarters, dandelion, goat's beard and barnyard grass.

All plots received an application of glyphosate (Roundup) at 2.5 kg active/ha on June 10 to control emerged weeds. Residual herbicides were applied on June 10 following glyphosate applications. Second applications were applied on August 6. Ratings were made on July 23 and September 28.

The most effective treatment in all three orchards was terbacil either applied once per season or twice per season. Combinations of ethalfluralin plus metribuzin, metolachlor plus metribuzin and metolachlor plus simazine were the second best treatments in the apple orchard of the 22 treatments tested. In the cherry orchard, the second best treatments included dichlobenil and linuron followed by paraquat or glyphosate of the 17 treatments tested.

Many of the late postemergence applications of graminicides (TF1195, DPX Y6202-31) did not effectively control emerged barnyard grass because it was too far advanced at the time of the application.

### 3. INGLIS, G.D. and BOLAND, G.J. - Biological control of Sclerotinia sclerotiorum in white bean.

The disease cycle of S. sclerotiorum involves the colonization of senescing tissues on the plant prior to infection. Fungi were isolated from white bean and canola blossoms and evaluated for their ability to interfere with the critical stage of senescing blossom colonization and thereby prevent disease development. Sterilized petals were co-inoculated with spore suspensions of S. sclerotiorum and the antagonist to be evaluated and were placed on white bean seedlings in a mist chamber. Twenty-eight fungal isolates were screened at least twice and 7 isolates prevented disease. To facilitate the screening of a large number of isolates, an in vitro screening technique was developed. A significant correlation was established between the mist chamber technique and the in vitro screening technique. Four hundred and fourteen fungal isolates representing 17 genera were screened in vitro and the best isolates were selected for field application. Field trials consisted of 5 experiments in 3 locations (total of 370 plots). The lack of an adequate infection period during the summer of 1987 resulted in minimal aerial infection by S. sclerotiorum. Survivability of applied isolates was determined and all isolates, with the exception of Penicillium sp., were recovered 2 and 7 days post-inoculation. Recovery of applied isolates, with the exception of Trichoderma sp., was significantly reduced between the two sampling times.

## 4. RIDDLE, G.E. and BURPEE, L.L. - Biological control of dandelions in turfgrass swards.

Observations suggested that dandelions are susceptible to species of pathogenic fungi that are not known to be virulent to turfgrass. Therefore, studies were initiated to assess the potential use of indigenous fungi as biological agents to control dandelions in turfgrass swards.

Controlled Environment Studies. Leaves excised from 8 week old dandelions grown in controlled environment were inoculated with 6 mm diameter discs of potato dextrose agar medium infested with isolates of plant pathogenic fungi. The inoculated leaves were incubated at 22°C in 100% relative humidity. The aggressiveness of an isolate was determined by measuring lesion size at 23, 42, 56, and 69 hours post inoculation. Virulence of 80 isolates was estimated by dividing the mean size of lesions produced by each isolate by the mean size of lesions produced by isolate number 30. Fifty-nine isolates were observed to be pathogenic on dandelion. Virulence varied among the isolates tested. Fifteen isolates were significantly ($P = 0.05$) more virulent than isolate 30.

Field Studies. The dandelion control potential of isolate 30 was evaluated on four 1 $m^2$ swards of dandelion-infested turfgrass. Applications of 100 $g/m^2$ of heat-killed perennial ryegrass seed infested with isolate 30 were repeated at 3 week intervals. Dandelion plants were counted in treated areas and in untreated areas immediately before each application. Mean % survival of dandelion plants was calculated.

Applications of inoculum of isolate 30 (100 $g/m^2$) reduced the population of dandelions in turfgrass swards by 50%. Surviving dandelions in the treated areas had smaller and fewer leaves than in the untreated areas. Isolate 30 had no visible effect on turfgrass during the course of the study.

Results indicate that isolates of plant pathogenic fungi can be used to reduce populations of dandelions in turfgrass swards. Additional studies on the epidemiology of disease in dandelions and on improved techniques for production of inoculum, will provide significant information leading to the development of a more efficacious bioherbicide.

### 5. LAWTON, M.B., BURPEE, L.L., and GOULTY, L.G. - Development of an effective dissemination procedure for the snow-mold-control agent, Typhula phacorrhiza.

Application of sterile grain infested with mycelium of isolate TO11 of Typhula phacorrhiza has resulted in significant suppression of gray snow mold in swards of creeping bentgrass. Research was initiated to formulate isolate TO11 into a potentially commercial biofungicide available for wide scale use. Results of experiments conducted in year 1 of the project indicated that small, uniformly sized, viable pellets containing T. phacorrhiza can be prepared. Information on pellet formulation and pellet viability in storage was obtained. Studies continued on the effect of storage on pellet viability and on methods to improve pellet efficacy in the field.

Laboratory Studies

Increasing the concentration of sclerotial fragments from 1% to 4% w/v in pellets decreased the loss of pellet viability (69% to 35%) after drying, and increased viability (16% to 45%) after 16 weeks in storage. At high sclerotial concentrations (4% w/v), pellet viability remained unchanged after storage for 16 weeks at -10°C, but decreased markedly after storage for 8-12 weeks at 20°C (room temperature). This decrease was lowest with pellets containing corn meal and calcium gluconate. Pellets produced from T. phacorrhiza grown in BASM broth had 100% viability after drying to a storable product.

Field Studies

Control of gray snow mold of turfgrass with pellets containing 0, 1, 2, or 4% w/v sclerotia, wheat hearts or corn meal as bulking agents, and calcium chloride or calcium gluconate as gelling agents was ineffective when applied to turfgrass at 2,000 pellets/$m^2$ in the 1986-87 season. Increasing the sclerotial concentration from 0 to 4% w/v provided a small but significant enhancement of disease suppression with corn meal/gluconate pellets.

Studies in progress designed to enhance the efficacy of sclerotial pellets for the 1987-88 season include: (1) corn meal/gluconate pellets applied to plots of creeping bentgrass at rates of 0, 1,500, 3,000, 6,000, and 12,000 pellets/$m^2$ and (ii) corn meal/gluconate pellets prepared with water or BASM broth applied to turfgrass at 6,000 pellets/$m^2$.

In the 1986-87 season, 37 isolates of T. phacorrhiza were evaluated for suppression of gray snow mold of turfgrass. Eleven isolates exhibited significantly greater disease suppression than the standard isolate TO11. In addition, plots infested with the eleven isolates required fewer weeks for the turfgrass to recover from snow mold injury than plots infested with T011. The effectiveness of mycelial pellets containing two isolates with enhanced disease suppression potential is being evaluated at the rate of 7,000 pellets/m$^2$ in the 1987-88 season.

### 6. BUTTLE, J.M. and HARRIS, B.J. - Metolachlor loadings to surface water: The role of watershed conditions and application techniques.

This report describes the results of a study of the transport of metolachlor under field conditions that began in 1986. The aims of the study are threefold: (1) to design, install and test a comprehensive field monitoring system for evaluating the hydrologic mechanisms associated with metolachlor transport from application site to receiving water bodies; (2) to examine the influence of application technique upon metolachlor export; and (3) to compare annual and short term loads of metolachlor and sediment under different watershed conditions.

The study area (a 5.5 ha field planted in corn (Zea mays L.)) is located approximately 15 km south of Peterborough at the mouth of a small (2.695 km$^2$) catchment. The site drains to a small water course, and has an average gradient of 6% and soils ranging from clay to loam in texture. The field was subdivided into two segments, and metolachlor (2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethylacetamide) formulated as Dual herbicide was applied to each segment at a rate of 2.75 l/ha. Segment 1 (1.4 ha) received the herbicide as a preemergence surface broadcast treatment (PRE), while metolachlor applied to segment 2 (4.1 ha) was incorporated to a depth of 5 cm prior to planting (PPI). Planting was cross-contour in segment 1 and parallel to the slope contours in segment 2.

Sampling for metolachlor persistence in soil was conducted in four zones: whole field PRE, whole field PPI, a footslope zone bordering the receiving water course, and an ephemeral stream channel that cuts across the PPI segment. Samples were taken prior to application, 1 h after application, and at intervals of 1, 2, 3, 4, 6, 8, 10, 12, 16, 20 and 24 weeks following application. Field runoff plots designed to isolate Horton overland flow (HOF) and saturation overland flow (SOF) in each segment were installed and monitored for metolachlor and sediment losses. V-notch weirs were installed at the base of the field in order to intercept and sample flow from the two segments prior to entry to the receiving water course. Tile drain and water course outputs were monitored by spot sampling supplemented by automatic pumping samplers during storm events. Continuous on-site recordings of temperature, relative humidity and precipitation amount and intensity were made during the study period.

Results from the 1987 field season should be considered in the context of the previous year's results. 1986 experienced above-average rainfall in May and June, resulting in high water table elevations at the time of herbicide application. Substantial rainfall events were recorded throughout the summer. The footslope zone was found to have slightly higher metolachlor concentrations than the whole field values during the study period, and both whole field and footslope levels showed a gradual decrease over time. Early season runoff responses from the HOF and SOF plots were comparable, while the HOF plots tended to generate relatively more runoff as the summer progressed. Highest metolachlor concentrations and loads occurred early in the season from the SOF plots as a result of high water table levels and frequent surface saturation during rainfall events. Peak discharges and metolachlor concentrations from the tile drains were observed shortly after the application date. By early July tile drain contributions of metolachlor to the water course were negligible, and total inputs over the study period were estimated to be <5% of the total herbicide load of the stream. Runoff plot data suggest that >90% of the total metolachlor input to the stream was transported as overland flow. The highest export rates occurred during the events of early June, and the total metolachlor export from the field was estimated to be <1% of applied active ingredient.

Climatic conditions during the 1987 field season differed significantly from those of 1986. Lower water table elevations were observed at the time of application due to below-average rainfalls in May, and fewer rainfall events occurred during the study period. Soil metolachlor concentrations in three of the sample zones (whole field PRE, whole field PPI and the ephemeral stream channel) exhibited the expected decrease with time. However, concentrations in the footslope zone increased throughout late-June and July, dropping abruptly in August. This pattern appears to be the result of downslope variations in the transport of sediment and metolachlor. Only the upslope HOF runoff plots responded to rainstorms in June and July. No runoff was generated from the SOF plots during this period due to lower water table elevations (relative to 1986) and reduced ground slopes. Thus the increases in metolachlor concentrations in footslope areas appear to be the result of the deposition of metolachlor adsorbed on soil particles eroded from upslope sites. Large rainfall events from August 7 to 10 led to a sharp rise in water table elevations and runoff and sediment yields from the SOF plots, indicating that metolachlor-enriched soil was flushed into the water course. These late-season events resulted in the highest metolachlor loads observed in the stream, in contrast to the 1986 results. Tile drain loadings of herbicide also peaked at this time (maximum concentrations of 17 ug/1), and preliminary results suggest that tile drainage contributed a relatively higher proportion of the total metolachlor load of the stream compared to 1986, due to the reduced number of overland flow events. Total metolachlor export from the study site is anticipated to be less than in 1986.

Analysis of the influence of application technique upon plot and whole-field losses of metolachlor is ongoing.

### 7. EDGINGTON, L.V. and BANKS, E. - Potential of flooding for controlling nematodes and fungi in organic soil.

Incidences of two carrot pathogens, the northern root-knot nematode (Meloidogyne hapla) and Rhizoctonia croccorum ,the cause of violet root-rot, increased in some fields in the Holland Marsh in the last two years. Our objective was to evaluate the effect of flooding on survival of nematodes and on the white mold (Sclerotinia sclerotiorum).

Effect of flooding on the root-knot nematode

A field located at the Bradford marsh was used in this study. An area of 300 $m^2$ which was heavily infested with this pathogen was flooded from November 1987 until March 1988. Ten soil samples were taken before flooding (August 1987) following a rectangular pattern (30 x 10 m). Four soil samples (10 m apart) were obtained from each of the longest sides of the rectangle and two samples were taken inside this area. After flooding in May 1988, the soil was sampled again. Normally, the populations of nematodes in Ontario reach a peak at the end of May. The samples of May 1988 were obtained from the same sites as those of August 1987. Densities of nematodes in the soil were estimated the Vineland Research Station. Data were statistically analyzed using a paired t-test.

Densities of nematodes in the soil decreased by about 50% during the period of the flooding (Table 1). However, in spite of finding significant differences (P = 0.05) in numbers of nematodes between the two sampling dates, the sufficient nematodes survived flooding to induce disease in susceptible crops. If a field is heavily infested with the root-knot nematode, winter flooding should be used in combination with crop rotation and/or nematicides and a soil analysis must be done to determine the density of nematodes before planting susceptible crops.

This experiment was conducted within a grower's field and an unflooded control plot adjacent to the sampled area could not be established. Further studies are necessary to determine the effect of fall or spring flooding on nematodes with appropriate control plots.

Effect of spring flooding on white mold of carrots

This experiment was conducted in ten microplots of muck soil (1.6 $m^2$ each) located at the Arkell Research Station, Guelph. To determine sclerotial survival after flooding, four small nylon bags containing sclerotia and 2 g muck soil each were buried in each microplot at a depth of 7 cm. Five microplots were flooded for 3.5 weeks during the spring of 1988 (April 25 - May 20). The remaining five microplots were left as unflooded control.

Table 1. Densities of root-knot nematodes in a Bradford field soil before and after winter flooding.

| | Number of nematodes per 50 ml of muck soil | |
|---|---|---|
| Samples | Before flooding (August 1987) | After flooding (May 1988) |
| 1 | 1360 | 80 |
| 2 | 240 | 20 |
| 3 | 0 | 120 |
| 4 | 0 | 320 |
| 5 | 120 | 3060 |
| 6 | 3500 | 7950 |
| 7 | 37700 | 8230 |
| 8 | 11160 | 5980 |
| 9 | 80 | 340 |
| 10 | 40 | 120 |
| Total | 54200 | 26220 |

Table 2. Percentage survival of sclerotia in flooded and unflooded microplots.

| | Replicates | | | | | |
|---|---|---|---|---|---|---|
| Treatments | 1 | 2 | 3 | 2 | 5 | X |
| Flooding | 20** | 15 | 15 | 10 | 5 | 13 A* |
| Control | 70 | 85 | 80 | 80 | 75 | 78 B* |

** Average of four observations.

* Significant differences (P = 0.05) between both treatments.

After flooding, the microplots were drained and the bags recovered from the soil. The bags were surface sterilized with 3% sodium hypochlorite for 12 minutes and then rinsed 3 times with sterile distilled water. Survival of sclerotia was determined by placing them on potato dextrose agar.

The results of this experiment indicated that flooding for 3.5 weeks during the spring was effective in decreasing the inoculum concentration of the white mold fungus in organic soil ( Table 2). Significant differences were found between the two treatments. To decrease survival of sclerotia in flooded fields even more, a longer flooding period should be evaluated.

### 8. ELLIS, C.R. - Winter survival and economic thresholds for corn rootworms in field corn.

Winter Survival

The objective was to determine the feasibility of monitoring winter survival of corn rootworm eggs as part of an IPM program. Specifically, our goals were to determine if significant differences in overwintering occur between fields, the cost of estimating these differences, and their usefulness in making pest management decisions. Approximately 10,000 rootworm eggs that were buried in mesh bags in cornfields throughout southwestern Ontario in Fall 1986 were recovered in spring 1987 and observed regularly for hatch. Results of this first full-scale test indicated some differences in winter survival between fields, but results were too variable to be conclusive. A number of factors other than the particular field significantly influenced egg survival. These factors included tillage, habitat, differences between batches of eggs and differences in storage time after the eggs were recovered from the soil. The experiments, however, were useful in redefining the protocol for any monitoring program. On the basis of our last winter's results, about 13,000 more eggs were buried in mesh bags this fall. In summary, our results are inconclusive, but experiments in place this winter are expected to satisfactorily complete this research.

Economic Thresholds

We obtained a third year of data relating beetle numbers on corn plants in August with damage the following year. Of the 21 fields of corn that were monitored for beetles last year, seven were lost due to changes in plans of cooperators. (Poor corn prices and our monitoring contributed to the decision of growers to rotate out of corn.) Comparison of treated and control strips of corn in the remaining 14 fields, showed that only five had high enough root ratings to suggest economic damage. More extensive data on root ratings and yields in these fields showed two with damage. These fields has maximum beetle numbers of 1.1 and 1.2.

This third year of data was similar to that previously reported to OPAC. There is not a good correlation between beetle numbers in August and subsequent damage the following year. However, again in 1987 there was no damage in cornfields where there was less than one western equivalent the previous August. This part of the research is completed; the no-damage threshold of one beetle per plant can be used with some confidence based on three years of data.

Our second objective relating to economic thresholds was "to determine the best way of defining beetle populations, not requiring treatment". Our earlier research was based on monitoring 3 or 4 times in August and expressing beetle numbers as the average number of beetles per plant. The repeated visits to fields, however, were not cost effective. Analysis of our three years of monitoring data confirmed reports in the USA that beetle counts can be delayed until pollen shed of corn in the fields. In all instances our beetle numbers during pollination were as high as during the weeks before pollination. (i.e. There is little likelihood of missing large ovipositing populations that disperse from the fields before sampling begins.)

For increased protection against economic losses in fields where no treatment is advised, we have adjusted our threshold to the maximum average number of beetles found on any sampling date rather than the average seasonal numbers. To optimize our sampling effort, if a field is above one beetle per plant, we recommend treatment and the field is not revisited. If there is less than one beetle per plant on the first visit, then the field is checked again in a week to ten days. This method avoids wasting our time on fields that are above the economic threshold, and enables scouts to concentrate their second set of samples on fields with a good likelihood of not requiring treatment. The computer program has been adjusted accordingly and was used by the Ontario Ministry of Agriculture and Food in their pilot project this year. The project on beetle monitoring was completed.

Larval Movement

The intent expressed in the last OPAC application was to support this part of the total research program on corn rootworm from another source but this was not successful. However, this research was an essential part of the program in support of IPM on field corn. With the help of some department support of the graduate student, and some adjusting of the OPAC budget, this project was continued with OPAC help.

Our hypothesis was that differences in the establishment of the newly hatched larvae in June contribute significantly to the differences in rootworm damage between fields. This research, therefore, supplements the research on winter survival, and will indicate which is the best target for monitoring. We have determined the effects of various soil factors such as moisture, soil type, and bulk density on movement of first-instar larvae through the soil. Within the range of soil conditions that are encountered in cornfields in June, there is, in fact, great variation in the amount of larval movement in the soil. For instance, both wet and dry conditions limited the movement of larvae which was optimum at 24% soil moisture by weight. Bulk density, on the other hand, had little effect under our conditions. This part of the overall research project will be finished by spring.

### 9. FAULKNER, P., ALLEN, W.R., and TRIMBLE, R.M. - Development of a monoclonal antibody probe for eggs and larvae of the parasite Pholetesor ornigis weed (Hymenoptera:Braconidae).

The spotted tentiform leafminer, Phyllonorycter blancardella (F.), is a commercially important pest of apple trees in most Great Lakes and eastern maritime regions. Control has relied solely on the use of chemicals to which most leafminer populations are developing resistance. To combat resistance, the use of broad spectrum pesticides has increased, with the result that population levels of natural enemies of the leafminer have been reduced to levels where natural control of the pest is no longer significant. Additionally, this situation has led to increasing control problems with pest mites, since population levels of predacious mites have been similarly reduced by the use of broad spectrum pesticides. Consequently, the number of miticide applications has increased by as much as six-fold.

With the knowledge that a braconid endoparasitic wasp, Pholetesor ornigis, has successfully maintained leafminer populations below damaging levels in unsprayed orchards, a project was developed to determine if control by the parasite could be incorporated into pest management strategies, thereby reducing dependence on pesticides and favoring re-establishment of other biological control systems. To this end, we sought to develop an assay procedure that would facilitate both early detection and reliable estimations of the prevalence of parasitism in orchards, thus aiding in decisions on the need for pesticides and their timely use. A similar assay also was required to investigate the significance of various observations, such as the increased sensitivity to pesticides exhibited by parasitized leafminer larvae among both pesticide resistant and susceptible populations. The procedure of choice had to be both sensitive and specific for the parasite, and be easily handled by technical and extension personnel. It had to be capable of handling large and variable numbers of specimens in relatively short periods by one or at most several persons, and, as an alternative, had to facilitate testing of stored specimens to accommodate seasonal shortages in manpower. The long term benefits to be realized from the development of such an assay procedure would be a precise understanding of the parasite-host relationship and the effects of horticultural practices on this relationship.

A serological assay procedure was considered the choice for meeting the test requirements. In order to develop the procedure, a supply of high quality antisera had to be produced. This phase of the project was carried out in 1987 under an OPAC grant received by Dr. Peter Faulkner of Queen's University. He and his staff utilized monoclonal antibody technology to produce a library of hybridoma cell lines that produced antibodies to parasite eggs or larvae. These cell lines were developed from mice that had been immunized with washed parasite eggs that were chemically disrupted by a procedure developed by one of the grant co-recipients (Dr.W.R. Allen). These antibodies will be used in the second phase of the project which will entail both the development of the serological assay procedure and its field evaluation at Agriculture Canada, Vineland Station.

### 10. **FITZ-JAMES, P., ATKINSON, M. and BYRNES, J. - Yield studies of a putative corn rootworm pathogen.**

Unusual Bacillus isolates were recovered in 1983 by Drs. Aronson and Dunn of Purdue University from an "organic" farm in Indiana where cornfields not treated with pesticide were continually free of western corn rootworm (WCRW) damage. Neighbouring acreage in which WCRW was chemically controlled failed to yield these particular isolates. The various isolates proved to be a unique species of Bacillus laterosporus forming an unusual parasporal body. In preliminary laboratory and greenhouse studies we demonstrated that this bacterium could protect corn plants from the damage of Western Corn Rootworm (Diabrotica vergifera). However, some laboratory tests at Purdue University and a preliminary field test at Ridgetown failed to confirm our initial positive findings. Failures appeared related to dose, time and method of inoculum application.

In 1987, 12 plots, were established in a field that had grown sweet corn for the past 6 years without pesticide application. Each plot contained 4 rows 4.6 m long and .8 m apart and were spaced 1.7 m from neighbouring plots. All plots were seeded with OHIO 43 corn seed on May 26th. Diabrotica eggs taken from 2-4$^{o}$C storage were spread on filter paper strips (20 eggs/strip) on May 22 and incubated at R.T. with high humidity in the dark for hatching (80%) on June 4 at which time most corn shoots were showing. Controls consisted of one plot with corn only, two with corn plus WCRW and one WCRW plus Counter insecticide (12-20 gr/row). Other plots were treated prior to the addition of the about-to-hatch egg papers with both sporulated and vegetative (log) cultures of the test strain and with control cultures of regular Bacillus laterosporus. Concentration of cells or spores varied from 2 x $10^{7}$ to 1 x $10^{11}$ per metre of row. Egg papers were placed 1-2 cm from the developing roots. Height of the corn was measured weekly and the cobs were weighed on October 20. The best control growth performance was shown by both the corn without added worms and the Counter treated plots. Height of plants unprotected by our test culture or treated with ordinary B. laterosporus was suppressed about 14% on average but were suppressed 20-22% at days 22 to 42 after seeding. Suppression of WCRW in plots treated with $2 \times 10^7$, $10^{10}$ or $10^{11}$ spores plus inclusion of the test B. laterosporus / m of row was zero, slight and moderate respectively. Yields of corn given the high dose were similar to those treated with Counter. The vegetative culture added at $10^{10}$ cells /m of row showed full protection of growth and a 29% improvement of corn yield over the unprotected controls.

A second field comparison of corn growth from July 9 to September 14 in rows of 30 plants grown in soil with and without a weeks pretreatment of the soil with spore and with vegetative cultures confirmed that the inclusion-free regular B. laterosporus showed no protection but that in $A_5$ treated soil (vegetative and spore) corn with WCRW grew at a rate equal to that of uninfested plants.

Separate laboratory tests indicated no immediate toxicity when larvae (2nd and 3rd instar) were exposed to spore and inclusions or purified inclusions of $A_5$. Late additions of culture to infected corn were unprotective. The apparent protective effect of $A_5$ in growth studies suggests the culture, in vegetative form, either invades the very young larvae for immediate or later damage or that it blocks the receipt of response of the worm to the corn root signal that directs it to the roots.

### 11. FRANK, R., BRAUN, H.E., CLEGG, B.S., and G. RITCEY - Studies on the disappearance of Pyrazophos, Oxyfluorfen and Oxidiazon.

Pyrazophos: Residues of pyrazophos were measured on chrysanthemums grown in a commercial greenhouse in the Vineland area. No disappearance was observed over the 14 days before sale. A second experiment was set up at the University of Guelph to measure the disappearance of pyrazophos over a 40 to 50 day period. In this experiment, residues appeared to be declining with a half-life of 19 to 25 days. A third experiment will be set up to check earlier work on dislodgeable residues that indicated between 2 and 7% was removed by gloves after 14 days.

Oxyfluorfen: Oxyfluorfen was applied to onions and soil at 312 and 625 ml/ha in each of 4 applications between 9 June and 29 June 1987. Samples of soil and onions were analyzed at varying times until harvest. Residues of oxyfluorfen disappeared rapidly from onion tissues and were below 0.1 mg/kg in 1 to 4 days. Residues in the soil surface (0-5 cm) declined with a half-life of 10 to 25 days.

Oxidiazon: Oxidiazon was applied to onions and soil during 1987 and samples were taken. A method of analysis was worked out and samples were analyzed on the spring of 1988. Oxidiazon residues disappeared from onions in 7 to 14 days and residues in soil declined from 4.7 ppm to 1.4 ppm in 141 days.

### 12. FRANKENHUYZEN, K. van, and NYSTROM, C. - Effects of post-spray weather on persistence of Bacillus thuringiensis (B.t.) on coniferous foliage.

Effectiveness of aerial B.t. applications to control spruce budworm is limited by rapid degradation of spray deposits. No persistence data are available for the recently developed high potency formulations which are the mainstay of current forest protection programs. These formulations are applied undiluted and may impart better foliar persistence by virtue of the higher concentration of active ingredient in the spray droplets.

This study was initiated in 1986. Residual toxicity of aerially applied Thuricide 48LV on white spruce was less than 2 days, despite moderate weather conditions. Simulated field experiments with laboratory-sprayed potted balsam fir confirmed that Thuricide deposits are highly susceptible to wash-off by rain. In 1987 experiments were conducted to quantify the effects of sun and rain on persistence of water- and oil-based formulations and to test the effectiveness of sticker adjuvants to prevent wash-off by rain. The relative contribution of sun and rain was examined by placing sprayed seedlings in various shelters providing a covered (no sun or rain), sheltered (sun only) and exposed (sun and rain) treatment. The effect of stickers and formulation type was investigated in the exposed treatment. Residual toxicity was assessed at regular intervals by bioassay of foliage against spruce budworm larvae.

Comparison of residual toxicity of Thuricide 48LV in the various sheltering treatments revealed that rain was more important than solar radiation in determining foliar persistence. There was little or no loss of toxicity on covered foliage (no sun or rain). The difference in residual toxicity between covered and sheltered foliage (loss due to sun) was always less than the difference between sheltered and exposed foliage (loss due to rain). As little as 0.5 mm of rain caused a 25% loss while 5 mm and 10 mm caused a loss of respectively 50 and 85%. Solar radiation usually accounted for less than 20% of the observed reduction in toxicity to budworm. Activity half-life of Thuricide 48LV on exposed foliage varied from 1 day under rainy conditions to almost 5 days under predominantly sunny conditions.

Reduction in residual toxicity on exposed foliage was similar for two water-based formulations (Thuricide 48LV and Dipel 8AF). An oil-based product of equivalent potency (Dipel 8L) appeared less susceptible to rain up to 10 mm, presumably due to better spreading and adhesion of the droplets.

Protection from wash-off by rain through addition of latex-based sticker adjuvants was variable. Bond (Loveland) did not offer significant protection against rain varying from 1.5 to 56 mm. Rhoplex AC33 NP (Rohm and Haas) and RA1990 (Monsanto) offered measurable protection up to 10 mm of rain. Neither of the stickers affected potency of B.t. in the spray mixture.

This study has demonstrated that wash-off by rain is more important in causing loss of residual toxicity than inactivation by sun. Persistence of the new high potency formulations is not much better than persistence of older less concentrated products. The water-based high potency formulations need stickers to prevent wash-off by rain. Suitable stickers are available and should be incorporated during formulation of the product.

### 13. GAYNOR, J.D. - Atrazine and metolachlor dissipation under three tillage systems.

A study was initiated in 1987 on Brookston clay loam soil to investigate the effect of three tillage practices on surface and subsurfaces losses of atrazine and metolachlor applied to corn. The Brookston soil is representative of 59% of the area under agricultural production in southwestern Ontario. The treatments consisted of two 0.1 ha replicated plots for each tillage practice (conventional tillage, ridge till, minimum till, and sod) on a poorly drained soil tiled at a depth of 60 cm at 12 m centres. All plots were graded so that surface water was channeled to an individual collection area at the head of the plots where it passed through a weir to record surface flow. Tile flows from each plot were monitored manually at outfall collection locations. A rainfall recorder is located at the site and a complete weather station (soil and air temperature, solar radiation, rainfall, and wind speed and direction) is located at the Whelan Experimental Farm within 300 m of the site. Thus, a water balance for each plot can be related to environmental conditions. All surface and subsurface water from the plots is channeled to a central collection facility where it is pumped to a drainage ditch. For each rainfall event water samples for pesticide analysis are manually collected from each treatment and stored for analytical analyses at the Harrow Research Station. Soil samples from each treatment are also collected through the growing season for herbicide residue determination.

Soil and water samples are analyzed by GC fitted with a thermionic nitrogen specific detector. A GC/MSD is used for confirmation of analytes.

Soil samples collected before application of the herbicides contained residues of atrazine from the previous cropping year. The ridge till treatments had residues of 59 and 28 ug/kg of atrazine on the tops of the ridges and in the ridge valley, respectively. Des-ethyl atrazine concentrations were 33 and 23 ug/kg, respectively. Atrazine residues for conventional and minimum till plots were 28 and 39 ug/kg, respectively. Corresponding des-ethyl atrazine concentrations were 24 and 22 ug/kg. The sod treatment which had received no atrazine had 5 and 31 ug/kg of atrazine and des-ethyl atrazine.

Corn (Pioneer 3707) was seeded at 62000 plants/ha on May 13, 1987. Atrazine and metolachlor were applied preemergence at the same time at 1.8 and 2.64 kg a.i./ha, respectively. Three minor rainfall events were monitored between May 14 and June 26 and tile runoff samples were collected. The first major runoff event occurred June 29. Nine more runoff events were monitored before December 31, 1987. Also, soil samples for herbicide residue analysis were collected during the growing season. All water samples and part of the soil samples have been analyzed for atrazine, des-ethyl atrazine, and metolachlor but results on all matrices have not been calculated at this time. Corn was harvested at the end of the growing season and yields calculated for each of the tillage treatments.

Soil residues after herbicide application were 769, 974, and 1442 ug/kg atrazine on the ridge, minimum and conventional till plots. Metolachlor soil residues were 935, 1139, and 1931 ug/kg, respectively. On October 5, 1987 atrazine (soil) residues were 55 and 39 ug/kg on ridge tops and in the ridge valley, and residues of 88 and 67 ug/kg were measured on the minimum and conventional till treatments. Corresponding metolachlor (soil) residues were 43, 37, 82, and 84 ug/kg, respectively.

### 14. HALL, R. - **Improved efficiency of chemical control of white mold of snap bean.**

The objective of the study was to determine the relationship between apothecia of Sclerotinia sclerotiorum in the field and the development of white mold in snap bean with a view to using this information to predict the necessity of fungicidal sprays in a particular crop. The disease was monitored in 12 plantings of cultivars Greencrop and Strike on one farm near Woodstock, Ontario. Observations were made weekly on five 10 m lengths of row per planting between July 13 and September 7, 1987. Four plantings developed white mold. Harvest dates were August 3 to September 7 for diseased plantings and July 20 to August 31 for healthy plantings. At harvest, diseased plantings contained much higher numbers of apothecia (average 1.2/m of row compared to 0.08/m of row) and denser canopies (100% observed a week before disease appeared. Disease incidence was highly correlated with the number of apothecia in plots in the week before disease (r = 0.98) and with the total of counts of apothecia over two weeks (r = 0.90). Diseased plantings retained blossoms a little longer and received less rain than healthy plantings. The later the harvest date between August 3 and September 7, the higher the incidence of disease. It is concluded that white mold in this trial was caused largely by apothecia within the field and was favoured by dense canopies and the onset of cooler weather. This information on the relation of apothecia, canopy density and temperature to disease could be used to predict the requirement for fungicidal sprays. In the present study, applications of fungicide would have been useful in only four of the 12 plantings.

### 15. HARMSEN, R., CLEMENTS, D.R. and Li, S.T. - Development of an integrated pest management module for the forecasting and control of phytophagous mites in apple orchards.

The introduction of new pesticides into apple orchards has destroyed previously effective IPM systems for the control of phytophagous mites. The synthetic pyrethroids seem to be highly toxic to predatory mites. In some parts of the USA and in the Netherlands new IPM methods have recently been introduced which restore the balance in the apple orchard mite complex. These systems are based on selected introductions of lab-reared pyrethroid resistant predators and the careful selection of appropriate pesticides.

Our attempt at formulating a similar IPM protocol for Ontario orchards has only just started. The first stage of our research has concentrated on the relationships of the European red mite (ERM) and two predatory mite species commonly encountered in Eastern Ontario orchards: Amblyseius fallacis and Zetzellia mali.

Experiments were conducted on isolated leaf discs in contained arenas in the laboratory. Both short term studies of one hour of continual observation, and longer term studies lasting for several days with intermittent recording were conducted. All necessary combinations of species and stages were tested so as to be able to assess potential predation effectiveness of either predator alone, or in competition with the other.

Of all the theoretically considered and tested interactions only surprisingly few actually take place, indicating a much simpler ecosystem than previously assumed. Zetzellia is essentially an egg predator: it will feed on ERM eggs, but is indiscriminate, and will also feed on A. fallacis eggs and even on its own eggs. A. fallacis on the other hand is an active predator which is particularly effective against protonymphs and males of ERM and of less (possibly insignificant) effectiveness against ERM females. They do not feed on any Zetzellia stages.

Further experiments involving other species of mite are currently in progress, as it is probably important to gain stability in IPM-managed mite species complexes through species diversity.

As soon as the 1988 growing season commences, we will continue similar experiments in the field, and before that, early in the year we will initiate the stage of this project leading to the production of pyrethroid resistant predator populations.

### 16. SIBLEY, P.K. and KAUSHIK, N.K., - Toxicity of microencapsulated permethrin to selected aquatic invertebrates and methods for identifying microcapsules in aquatic habitats.

Summary of Research

Microencapsulated permethrin (common name: Penncapthrin) was tested for its toxicity against two lotic invertebrates, Simulium sp. and Hydropsyche sp. and two lentic invertebrates, Daphnia magna and Daphnia pulex. Stream invertebrates were exposed in flow through bioassays, using filtered stream water and Guelph tap water, for one hour which approximates the pulse dose likely to occur during agriculture or forest spray programs.

$LC_50$ estimates for Hydropsyche were 4.21 mg/l and 4.54 mg/l for tap and river water respectively. Corresponding values for Simulium, were 0.961 mg/l and 1.54 mg/l. Initially, these values may appear high, especially when compared to the high toxicity of the EC formulation of permethrin. We feel that several important factors, individually or jointly, account for this effect.

A major factor is test duration. A one hour exposure, although realistic from a stream contamination perspective, is likely not enough time for the release of a quantity of insecticide toxic enough to bring about substantial mortality. From the point of view of non-target invertebrates in streams, this is beneficial.

A second factor, also related to release kinetics, is that the short residency time of microcapsules in the digestive tracts of exposed organisms prevents the release of enough insecticide to bring about high mortality. Examination of this hypothesis can be achieved by employing identification techniques. For example, the senior author, in collaboration with Mr. C. Fortin (University of Guelph) has developed a staining technique and used various substrates including those ingested by organisms. For penncapthrin, worth with SEM has shown that the integrity of most microcapsules is maintained upon passage through the gut indicating that little insecticide is released. Corroboration of this information should be possible through insecticide time-release studies and residue analysis with chromatography.

A third factor, applicable to net-spinning Hydropsyche, is the size of microcapsules in relation to the mesh size of larval nets. Microcapsules of penncapthrin range in size from 10-75 um whereas the size of mesh varies between 100 and 500 um. As these ranges do not overlap, microcapsules pass directly through the net and thus are not ingested by the larvae. It may be interesting to compare these values with those derived from tests with other net-spinning Trichoptera such as the Philopotamidae (e.g. Dolophilodes sp. and Chimarra sp.) in which mesh dimensions are between 0.5 and 7 um.

A final factor may reflect the adsorptive nature of permethrin. Although exposure is only one hour, it is possible that some of the released insecticide is adsorbed to the walls of the test containers. Compounding this problem may be adsorptive tendencies of the nonpolar polymeric material comprising the microcapsules which would attempt to "avoid" interaction with the polar water environment. Again, chromatography is necessary to elucidate this possibility.

The acute tests with Daphnia have produced some highly variable results. For example, the average $LC_50$ estimate for D. magna was 0.285 mg/l but ranged from 11.8 ug/l to 16.8 mg/l. For D. pulex the average estimate was 13.2 ug/l with a range of 1.23 to 35.7 ug/l. One factor which may contribute to variation in these tests may be adsorption. The need to address this problem has been discussed above. Microcapsule size may also be important. For example, tests with a high percentage of large microcapsules, may restrict the number ingested by Daphnia and result in lower mortality. Conversely, tests with a high percentage of small microcapsules could possibly lead to higher mortality as more would be ingested.

There is a considerable difference in toxicity between lentic and lotic invertebrates. This most likely reflects test duration in which assays with Daphnia lasted either 48 (D. pulex) or 72 (D. magna) hours compared to only one hour for stream invertebrates. The duration of the former may be enough time for the release of a quantity of insecticide sufficient to bring about higher mortality relative to the one hour flow through tests. Clearly, microencapsulated insecticides would have their greatest impact on non-targets in lentic environments.

Very little research has been conducted on microencapsulated insecticides and little is understood about their behaviour or short-term toxicity (a notable exception is the research that has been conducted with Penncap-M in relation to bee poisoning). The preliminary data we have suggests that toxicity is influenced by: i) exposure time, ii) release kinetics and iii) habitat characteristics (e.g. net mesh size). It is possible that these characteristics are common to microencapsulated formulations in general such that a comparative study of several microencapsulated formulations would be beneficial.

### 17. KEVAN, P.G., EISIKOWITCH, D. and LACHANCE, M.A. - Yeasts and milkweeds: using yeasts to suppress fruit and seed-set in milkweeds.

Field milkweed, Asclepias syriaca, is a noxious weed and difficult to control. We discovered that the little known yeast, Metschnikowia reukaufii is potentially a biocontrol agent which may affect the fruiting capabilities of the plant. It is a natural symbiont which lives in the floral nectar. It is widespread, being found everywhere we have surveyed from southwestern Ontario to western Quebec and northern New York. Milkweeds are unique in that the stigmatic cavity is the nectary and that the nectar is the germination medium for the pollen. During pollination, which requires insects, the pollinia (special packages of pollen as produced by the plant) are moved from flower to flower as the insects forage for nectar. When the pollinium is inserted into the stigmatic cavity, its pollen may germinate and grow in the sugary nectar (ca. 20% sucrose), into the stigmatic tissue to eventually bring about fertilization of the ovules, seed-set, and fruit development. The yeast is also readily transported by pollinators such as bumblebees, honeybees, flies, and moths. Studies of pollinia in sugar solutions and in nectar from flowers that opened in the laboratory and so were yeast-free showed that they always germinated. However, if the yeast was inoculated into the sugar solutions or clean nectar the pollinia always failed to germinate, as was the case for pollinia in nectar collected from flowers which had opened in the field (80 - 90% failure). Experiments have confirmed that pollinators, honeybees at least, do not discriminate between sugar solutions with and without M. reukaufii. Field trials of spraying the yeast twice a day for the duration of the bloom of milkweeds were difficult to interpret because of high variability in the reproductive efforts in the natural populations of milkweed chosen. Further, we have found that M. reukaufii is also highly variable in laboratory culture. It may alter its form, but is generally highly proteolytic, lipolytic and osmotolerant. Several biotypes have been cultured at University of Western Ontario. Thus, M. reukaufii suggests itself as an easily vectored floral pathogen of milkweed and which has potential as an augmentative biocontrol agent for reducing seed-set, and hence renewed field contamination, by milkweed. To overcome the problem of variability in milkweeds, eight clones were chosen in the field around Guelph. From each, five splits were made, and each was planted in a planter box and cared for over the summer. This provides for eight known biotypes of A. syriaca for four controlled experiments with M. reukaufii on each. The milkweeds in their planter boxes are now under straw awaiting experimentation in 1988. Some yeast biotypes are in culture at the University of Western Ontario, also awaiting the 1988 field season. We also intend to expand our collection of yeast biotypes, and possibly milkweed biotypes as our research progresses.

**18. KINGSBURY, P.D., and BARBER, K. - Developing an implementation protocol for fruit-set of the forest wildflower Polygonatum pubescens in an insecticide impact monitoring program.**

Research into the pollination biology of Polygonatum pubescens was continued in 1987 to follow and build upon preliminary findings of the previous year. These indicated the potential for utilizing this species in monitoring studies evaluating impacts on insect pollinators. Although fruit-set was low in manually cross-pollinated flowers in 1987, this was suspected to be due to some uncontrolled fault in experimental technique- P. pubescens is still considered to be highly self-incompatible. Fruit-set was confirmed to be dependent upon access to flowers by insect visitors.

The relatively minor role of small-bodied insect visitors was implicated by the low fruit-set in flowers protected only by relatively coarse (1/4-inch mesh) hardware cloth. A list of insect visitors comprising one species of small beetle (Staphylinidae), seven species of flies (mostly Syrphidae), and two species of bumblebees (Bombus vagans and B. perplexus) was compiled from two years of data. Using manipulated natural visitation of flowers, bumblebees were found to be the effective pollinator component of the insect visitors.

Bumblebees were observed in the field to be capable of reaching the nectar in flowers of P. pubescens. Effective removal of nectar was demonstrated by measurement of nectar volumes in protected flowers and exposed flowers. Very few of the bumblebees observed foraging were found to carry pollen in their corbiculae suggesting the subordinate attraction or value of this floral resource to that of nectar. However, pollen appears to be the primary attractant for flies judging from the observation that they do not penetrate beyond the anthers as they graze pollen. Presumably, they seldom, if ever, contact the stigma or the nectar.

Comparative data on fruit-set from three other sites await detailed analysis. Preliminary results suggest a wide range of natural fruit-set (7-35%) which has not been correlated with any particular variable.

Polygonatum pubescens provides an alternative to Clintonia borealis as a lily-bumblebee pollination system which can be incorporated in a pesticide impact monitoring programme.

### 19. LAING, J.E. and WANG, T. - Establishment of the parasitoid Holcothorax testaceipes in Canada and assessment of its impact on Phyllonorycter blancardella.

Holcothorax testaceipes (Ratzberg) is an egg-larval parasitoid of the apple leafminer, Phyllonorycter ringoniella in Japan. This parasitoid was introduced to Guelph, Ontario in 1983 for biological control of the spotted tentiform leafminer (STLM), an important pest of apples in eastern North America.

STLM lay their eggs on lower surface of apple leaves and larvae develop through 5 instars. The first 3 instars are sap feeding, the last two are tissue feeding. H. testaceipes attacks only the eggs of its host and develops polyembryonically throughout the host's larval stages and emerges from a fifth-instar host.

Adult H. testaceipes were released into an orchard at Guelph over three consecutive growing seasons. Laboratory and field studies have indicated that the parasitoid is able to develop on STLM and has become established in the orchards.

Releases were made in the University of Guelph Research Orchards containing either semi-dwarf or standard apple trees. Since H. testaceipes completes development and becomes visible only during the host's tissue-feeding stages, only these larvae were sampled to determine mortality and construct the life tables for each generation of STLM. During 1986 and 1987, the date of initial sampling was determined by a small weekly pilot sample and data of STLM adult flight from pheromone traps.

H. testaceipes became well established at the release site during 1986 and was recovered from 13.8% of STLM, during the third generation, however, it did not spread readily to the "control" block. During 1987, H. testaceipes outcompeted chalcids and Pholetesor species to become dominant during the overwintering generation. Mortality factors observed during the tissue-feeding stage but impossible to identify were categorized as residual deaths (e.g. predation, disease, etc.) in the partial life tables.

H. testaceipes showed a limited dispersal during 1986. For instance, 13.8% of the overwintering generation were parasitized in the release block but only 1.2% in the "control" block. During 1987, however, parasitism by H. testaceipes increased on STLM's overwintering population compared to 1986, and became more uniform throughout the two blocks.

Parasitism due to the different species of parasitoids was not fully additive: wherever H. testaceipes parasitized a high percentage of its host, other parasitoids (mainly Pholetesor spp.) showed a drop in parasitism and vice versa. However, higher parasitoid diversity could result in a more stable biological control system regulating the spotted tentiform leafminer in Ontario.

### 20. MAKEY, S.R., PITBLADO, R.E. and HASTIE, G.M. - Development of a weather-timed fungicide spray program in field tomatoes.

A model, referred to as TOM-CAST to time the application of fungicides in field tomatoes was developed. The target diseases are Early Blight Alternaria solani, Septoria Leaf Spot Septoria lycopersici and fruit Anthracnose Colletotrichum coccodes. The model identifies when to apply the first and subsequent sprays. It has been developed using leaf wetness and temperatures as the criteria for timing fungicides rather than the more traditional fixed calendar spray recommendations.

TOM-CAST uses laboratory components developed by Madden, Pennypacker and MacNabb (1978) and Waggonner and Horsfall (1969) for the determination of Disease Severity Values (See last year's report). A leaf wetness sensor designed by T.J. Gillespie and G.E. Kidd, University of Guelph and manufactured at RCAT is used and with the aid of an Omnidata datapod Model DP223, hourly leaf wetness and temperature readings are tabulated for the calculation of daily Disease Severity Values. Our objectives were this year to field test TOM-CAST, determine the rates of dissipation of currently-used tomato fungicides and to compare the effectiveness of "home-made" and commercial wetness sensors.

Field Testing TOM-CAST

Ten tomato growers cooperated in comparing their regular spray program to that with timings determined by TOM-CAST. Three weather station locations were chosen and growers were to reference only one location closest to their operation. Disease severity values were calculated and recorded on a code-a-phone system and updated 3 times per week.

The method of recording and making the information available to growers through a code-a-phone system worked well. Growers were able to call and record the TOM-CAST disease severity values at their convenience. Spray-timing by TOM-CAST and by the conventional method were similar. This may be explained either by the type of cooperators selected who, through years of commercial experience, have learned to space their spray applications depending on the weather and/or a tendency for growers to follow along with the TOM-CAST program for their commercial spray timings. The summary assessment data indicated no significant differences in foliar disease ratings, anthracnose nor yield. Growers indicated an interest in the TOM-CAST fungicide spray program as a management tool that could be incorporated into their farm system.

In the initial developments of TOM-CAST, three fungicides were tested with emphasis on Difolatan 480F, the predominant commercially used tomato fungicide. Under the current registration status, Difolatan 480F will be phased out, no longer available to Ontario tomato growers. This year, therefore, increased emphasis was placed on the other two fungicides Bravo 500 and Dithane M45/Manzate 200. Trials indicated that both will function under TOM-CAST with some adjustments favouring additional application requirements for Dithane M45/Manzate 200 to achieve comparable control to that of Bravo 500.

## Rates of Dissipation of Fungicide

To better understand the intricacies of chemical control strategies we followed the rates of dissipation of chlorothalonil (Bravo 90DG) and mancozeb (Dithane M45) over a 14 day interval. Fungicides were applied once in July and once in August on separate areas within a field and leaf samples were collected from the outside and inside of the foliar canopy prior to, immediately after, 1, 3, 7, 10 and 14 days after spraying.

During the sampling period, July 13-27, similar degradation curves were observed during the first 3 days for both chlorothalonil and mancozeb. By the 7th day of sampling residues of both fungicides had significantly dissipated. The level of chlorothalonil was, however, slightly higher than that of mancozeb at the 7th, 10th and 14th days. Residues on the interior or inside leaves were significantly lower than on the outer leaves early in the spray program.

During the sampling period, Aug. 10-24, the tomato plants were beginning to senesce especially by the 10-14 day period. Chlorothalonil residues were similar to those in the sampling period in July with high levels observed until the 7th day. Mancozeb residues dissipated much faster in the August sampling period showing significant losses with 48 hours of spray application. Less residues were observed on leaves within the plant canopy than leaves on the outside of the canopy.

Chlorothalonil residues were observed for longer periods on tomato foliage than the residues of mancozeb.

## Leaf Wetness Sensors

The leaf wetness sensor manufactured at RCAT and used throughout the TOM-CAST network was compared with the sensor developed and manufactured by Reuter-Stokes Inc. The leaf wetness sensor of Gillespie and Kidd was more sensitive to leaf wetness periods than was the Reuter-Stokes sensor. In June the Reuter-Stokes sensor identified leaves being wet 64.4% of the time when compared to leaf wetness identified by the RCAT sensor. Later in the summer when it rained more often, the Reuter-Stokes sensor improved its sensing capabilities to 77.8% of that of the RCAT sensor. There were intervals under light dew conditions where the Reuter-Stokes sensor did not indicate that the leaves were wet at all.

### 21. MBOGO, E.W., and KAKUDA, Y. - Effect of processing on cypermethrin residues in green beans and broccoli.

This research project was initiated in the Summer of 1987. The field experiments were carried out at the Cambridge Research Station, Cambridge, Ontario. Processing was done in the Department of Food Science, University of Guelph.

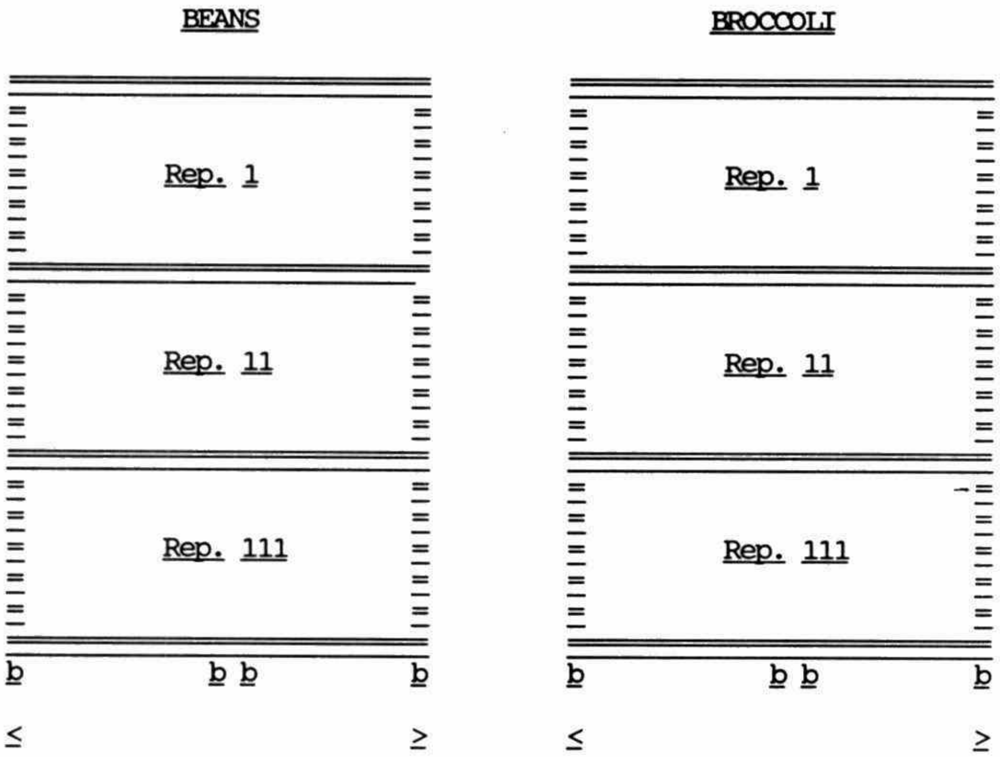
Both green beans and broccoli were grown in plots using a block design with three replications (Fig. 1). Planting dates were staggered to prevent the beans and broccoli and their corresponding replications from maturing on the same day thus avoiding overlapping harvesting, processing and extraction times. Both beans and broccoli were harvested three days (72 h) after spraying with cypermethrin [Ripcord 400 Emulsifiable Concentrate (E. C.)] at the rate of 140 g per hectare. Double the recommended rate of application was used in order to have a higher residue level at harvest so that changes due to processing would be easier to detect.

Pesticides were applied using a tractor mounted boom sprayer with nine overhead nozzles on 18 inch centre. Four rows were sprayed at a time using a sprayer volume of 800 litre per hectare and a ground speed of 2 miles per hour. Prior to the experimental application of cypermethrin, no other insecticide was sprayed on beans. However, cypermethrin was applied to replicates 2 and 3 of broccoli once on 17/8/87 at the recommended rate of 70 g per hectare.

Beans were harvested on 23/7/87, 30/7/87 and 7/8/87 and broccoli on 20/8/87, 25/8/87 and 28/8/87. In the laboratory, each crop was trimmed and cut into edible portions. The cut-up portions were thoroughly mixed and samples taken for the following processing treatments: steam blanching, hot water blanching, canning, dehydration, lyophilization, water washing and cooking. To study the influence of storage time on pesticide levels, samples were placed into glass jars and stored at refrigeration and freezer temperatures for varying lengths of time. Figure 2 shows the processing treatments used on green beans. A similar set of processing treatments was used on broccoli.

The extraction and clean-up procedure (Fig. 3) adopted for these samples was long and tedious (Braun and Stanek, 1982). Samples were taken before and after each processing treatment. Not all the samples could be worked-up completely on the same day; therefore, samples were extracted to a point where the procedure could be safely stopped, and frozen until time allowed. Stored samples (refrigerated and frozen) were cleaned-up on the day specified by the experimental design. The last sample was removed from storage on 26/11/87.

Figure 1. Field Layout



Rep. 1 = Replicate 1

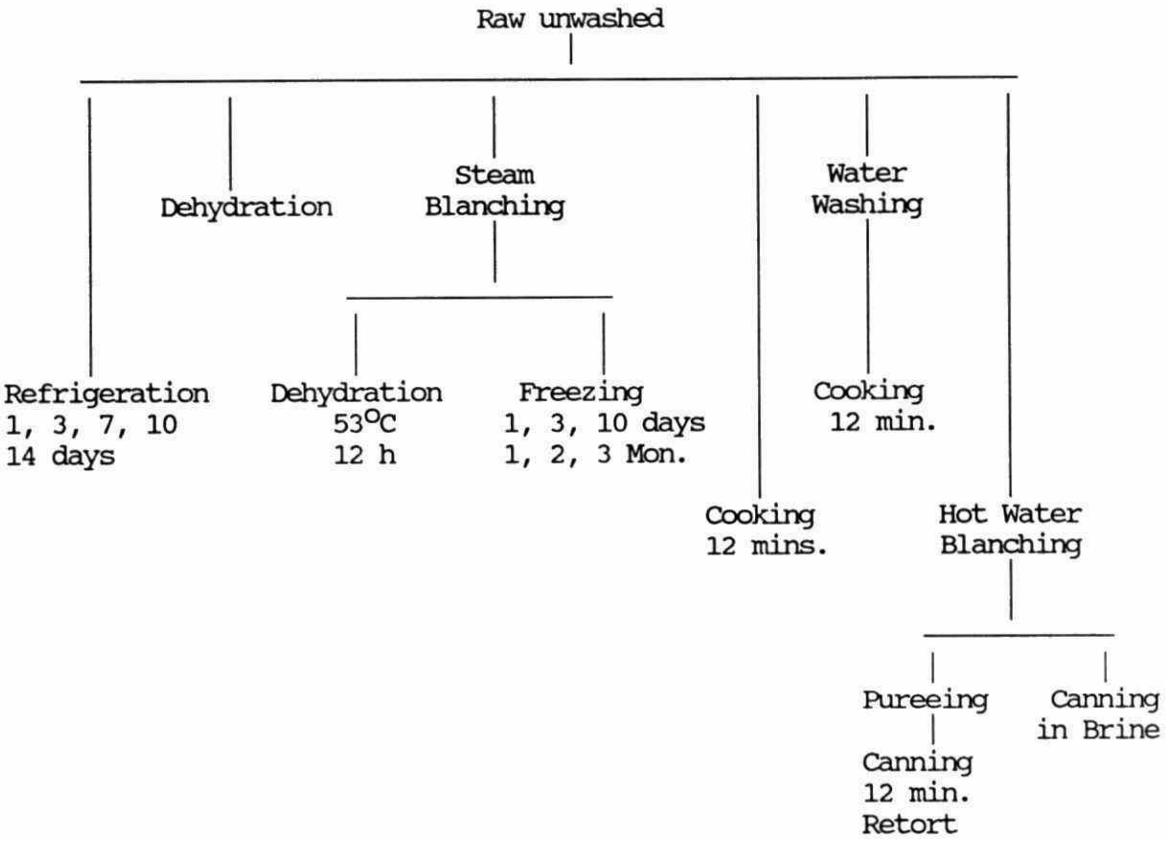
Rep. 2 = " 2

Rep. 3 = " 3

b = buffer rows

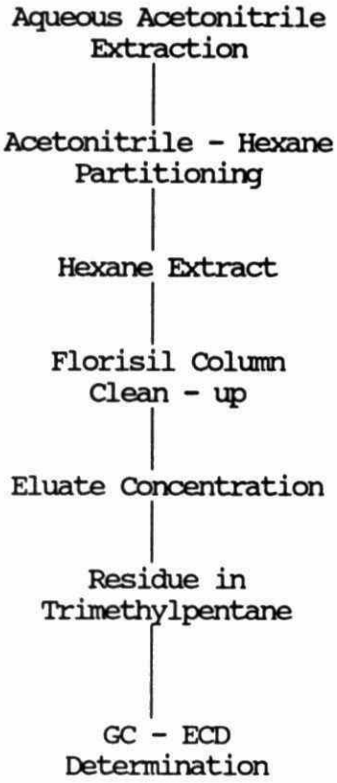
Each replicate consists of 12 rows of 73 feet

Figure 2. Sampling Points for Commercial and Home Green Bean Processing



Total No. of samples per replicate = 35
Total No. of analysis per replicate = 72

Figure 3. Analytical Method


Aqueous Acetonitrile Extraction
Acetonitrile - Hexane Partitioning
Hexane Extract
Florisil Column Clean - up
Eluate Concentration
Residue in Trimethylpentane
GC - ECD Determination

Sample weight = 50 gm

The planting, spraying, harvesting and processing were accomplished with very little difficulty. However, problems were encountered with the final gas liquid chromatography (GLC) analysis using an electron capture detector (GC -ECD) (Tractor Model 550). Owing to these problems, the results of analysis were not available, but the project will be completed by mid-summer, 1988.

### 22. MCLEOD, D.G.R., TOMLIN, A.D., TOLMAN, J.H. and WHISTLECRAFT, J.W. - Assessment of the potential of Aleochara bilineata for the control of root maggots in the home garden.

Aleochara bilineata (Ab) is a parasitoid of several root maggot species, including the cabbage maggot, Delia radicum (CM), and the onion maggot, Delia antiqua (OM). As release of Ab in commercial onion fields in Thedford to control OM met with limited success, it was decided to evaluate the effectiveness of Ab to control CM and OM in the more restricted environment of the home garden.

From 62 volunteers for the garden experiment, 24 were selected based primarily on garden size (400 - 1500 sq. ft.) and location within the city. They were divided into 3 groups. Ten comprised the Release group which received weekly releases of Ab, 10 in the Control group (no AB release) and 4 in the Intensively Monitored group (no AB release). The average garden size in each group was roughly the same and each group had equal numbers of "organic" and "non-organic" participants.

Ab reared on diapausing pupae of OM, were released in gardens at the rate of 1000/week/garden throughout the season (21 weeks) with the exception of weeks 3, 4, and 5 of the experiment, when only 600 Ab/week/garden were released. All beetles were marked with a fluorescent orange or green pigment before release to distinguish them from the natural population.

Four plantings of radishes and three plantings of onions were established for evaluation of CM or OM damage, respectively. Pests and parasitoids were monitored in all gardens with a yellow water pan trap and a barrier interception trap. A Masner flight interception trap was also included in the intensively monitored gardens.

Populations of native Ab in home gardens were very low with the exception of two gardens. Of a total of 74 unmarked, naturally occurring Ab captured all season in all gardens in barrier interception traps, 41 were caught in two gardens, 12 in number 18 and 29 in number 16. Yellow pan water traps were somewhat less efficient than barrier traps, capturing a total of 29 unmarked Ab, of which 6 were in number 16. This uneven distribution pattern, at present unexplainable, requires additional study.

Somewhat to our surprise, populations of the predatory tiger fly, Coenosia tigrina (Ct), were extremely high in the home garden environment compared to populations collected from commercial fields. A total of over 6000 Ct were captured in the 20 gardens, for an average of 300 per garden. Ct were caught in roughly equal numbers in Control and Release gardens. The effect of Ct on CM and OM populations is unknown, although it could be considerable as Ct consume 2-3 CM or OM adults per day in captivity.

The usual three generations of CM were reduced to two by the extremely hot weather during July and August. CM were, in general, widespread throughout the city but by chance, the average number of CM flies in the Control gardens were twice as high as in the Release gardens. Damage in the Control gardens due to CM was highest in the early season (39.8%) and decreased to an average of 5.8% in the last planting. Damage in individual Control gardens ranged from 0-73%.

Damage in Release gardens averaged 1/4 that in Control gardens (Release 2.8%, Control 15.5%). Although all plantings in Release gardens had less damage than Control gardens, the reductions were statistically different in only plantings 1 and 4. Poor germination due to very dry conditions, flea beetle damage, gardener and cat activity, and miscellaneous other problems reduced the total number of successful evaluations that could be included in the calculations thus reducing the efficiency of the statistical test. Damage in individual Release gardens ranged from 0-25%.

There were also only two generations of OM and populations were twice as high in Control gardens as in Release gardens. Early season damage in Control gardens was highest in the first onion sets (40.3%) and lowest in the bunching onions (5.2%). Damage in Control gardens averaged 22.1% over the season and ranged from 0-100% in individual Control gardens.

The average damage in Release gardens was just over 1/2 that in the Control gardens (Release 12.1%, Control 22.1%). The differences between Release and Control gardens, however, were not statistically significant because of the limitations mentioned above. Damage in individual release gardens ranged from 0-55%.

### 23. NEALIS, V. - Parasitoids and pest management of the jack pine budworm.

The recent outbreaks of the jack pine budworm (*Choristoneura pinus pinus* Free.) in Ontario have provided an opportunity to investigate the relationship between parasitoids and patterns of natural mortality in budworm populations. In addition, an experimental program has been initiated to answer specific questions pertaining to natural parasitism and pest control operations; improved forecasting, targeting and timing for insecticide application. The emphasis of this program is on the conservation of naturally-occurring parasitoids and the role of these parasitoids in collapsing populations of the jack pine budworm.

The first OPAC-sponsored project (1985) was the development of a sampling method to estimate mortality which was due to the occurrence of two common parasitoids overwintering within the budworm. The premise was that such a method would permit forecasting of natural mortality and allow pest control officers to identify areas where parasitism was high enough to make spray operations unnecessary. It was first necessary to define a sampling method for the overwintering stages of the jack pine budworm and then extend this method to the estimation of parasitism. This has been completed and a manuscript is in preparation.

The second project addressed the problem of spray timing. I was interested in demonstrating that, once a decision to spray has been made, careful timing could not only achieve good control but spare resident parasitoids. This first required the identification of instars in the jack pine budworm (Nealis, 1987, Canadian Entomologist 119:773) and development of a degree-day model for both the budworm and its parasitoids [Lysyk and Nealis, 1988, J. Econ. Entomol. (in press)] and then experimentation to determine the effect of different timings of the commonly used insecticide, Bt, on rates of parasitism in surviving budworm (with van Frankenhuyzen). The preliminary experiments show that, using conventional timing of the spray, there is differential survival of parasitized individuals. Thus Bt, as an insecticide, is complementary to natural mortality. By using our degree-day model we are now better able to design an experiment which will further refine these ideas and prescribe a spray window which takes maximum advantage of naturally-occurring parasitoids.

The current OPAC project, to elucidate the roles of parasitoids in collapsing jack pine budworm populations, is the most fundamental and challenging of the studies which have been initiated. But it is a crucial question which will impact on how we propose to manage this pest in the future. The study draws heavily on the theory and methods developed for population dynamics of the spruce budworm. This theory is relevant for jack pine budworm because the species of parasitoids involved are the same and both budworm pests exhibit systematic fluctuations in population densities. What is particularly interesting in jack pine budworm is the relative brevity of the outbreak phase and the abruptness of the collapse.

Following the severe and extensive defoliation by jack pine budworm in 1984 and 1985, populations collapsed dramatically, first in northeastern Ontario (1986) and then in northwestern Ontario (1987). Observations in 1986 revealed that parasitism in these plots was very high (>75%), particularly parasitism of the late-larval stages. These observations were pertinent because theory predicts that it is mortality in the late-larval stages which has the greatest impact on the subsequent population trend.

With the cooperation of the Forest Insect Disease Survey in Sault Ste. Marie, an intensive study of natural mortality in all life stages of the jack pine budworm in 6 unsprayed plots in northwestern Ontario was launched. In addition to the early spring samples which allowed testing of the sampling method for the overwintering parasitoids, branch samples were made at weekly intervals throughout the feeding period. These branches were returned to Sault Ste. Marie where all budworm and parasitoid cocoons were removed and counted. The budworms were reared on an artificial diet to determine the frequency and identity of the parasitoids present. We were thus able to determine seasonal trends in the density of budworm as well as stage-specific mortality. The results will be presented in more detail at the annual meeting but, in summary, each of the 6 populations were marked by high levels of parasitism throughout the larval and pupal stages. Parasitism in overwintering larvae ranged from 11-27% and this was confirmed by estimating these rates of parasitism again at the 3rd and 4th instar. The rates of parasitism were especially marked in the large larval collections (60-65%) and in the pupal stage (55-72%). It should be noted that expressing parasitism as a relative measure (percent parasitism) is fraught with quantitative difficulties. The biases that arise, however, inevitably lead to underestimation of the true frequency of parasitism. Although we cannot, therefore, give an exact value to the level of parasitism at any one stage, we can certainly conclude that parasitoids inflicted a significant level of mortality to the budworm and that the highest levels of parasitism occurred in life stages in which the impact of mortality on population trends was greatest. We also know that these populations have collapsed and therefore a correlation exists between high levels of parasitism and population declines.

The significance of these conclusions are considerable. If these patterns are common, then we can expect jack pine budworm outbreaks to be short-lived and the damage, perhaps tolerable. Even where spray operations are advised, one year's protection may be sufficient. There is good evidence that after 1 to 2 years of high population numbers, the parasitoids will increase to a level where a population collapse is imminent. Even if forecasts based on egg mass or overwintering larvae show a potential for defoliation, that defoliation will not ensue. Ideally, prediction of population trends so that we know when and where natural mortality will be sufficient to protect our trees is a primary applied goal of population studies. Although we are a long way away from that capability, the studies supported by OPAC have contributed significantly to our understanding of natural mortality in jack pine budworm populations and to the development of methods for more effective forecasting of natural control factors. Collectively, these studies form a decision-support system for pest managers facing limited operational resources and a responsibility to protect resources in an effective and environmentally sound manner.

## 24. SANDERS, C.J., - Development of sex pheromone traps for monitoring jack-pine budworm.

The long-term objective of this study, was to produce a system for monitoring fluctuations in jack-pine budworm population densities, similar to that now operational for the spruce budworm, which was developed with OPAC support. Such a system would permit the forecasting of impending outbreaks which would allow forest management to take action before the crisis stage.

The first step in the development of a sex phermone monitoring system is the identification of the sex phermone. As a result of an Ontario Ministry of Natural Resources contract in 1983 and 1984, the New Brunswick Research and Productivity Council (RPC) identified 4 components of the pheromone blend, but although various combinations and concentrations of these have been assayed, they do not approximate the attraction of a virgin female moth. RPC, and more recently, the chemistry department of Simon Fraser University (SFU), are continuing chemical analyses of natural pheromone extracts. The objective of this study is to provide the insects necessary for pheromone extraction and to carry out laboratory and field bioassays to determine the biological activity of chemical samples provided by the chemists.

One person was hired to work half-time for half the year on rearings. A total of over 75,000 second instar larvae were reared during 1987, yielding 15,000 pupae, which were shipped on a regular weekly basis to RPC. This required 11,000 cups of synthetic diet, for a total of 45 gallons of diet.

To bioassay chemical material, a new wind tunnel has been constructed, which allows testing on spruce budworm to be carried out independently of current experimentation in our laboratory. An effective bioassay has been developed. By holding insects at appropriate light/dark cycles, close to 100% of the males tested respond to calling females. The ultimate assay was to test candidate chemicals as lures in traps in the field.

Results to date have been disappointing. Laboratory wind-tunnel bioassays were carried out on chemicals provided by RPC and SFU, and both RPC and SFU provided chemicals for field testing in 1987. Virgin females were used as standards in these tests. They caught on average 13 males each; the most effective synthetics captured only 6 per trap, indicating the need for further chemical analysis.

Rearings to provide insect material for analyses and bioassays will continue until April 1, 1988. Field assays will be carried out during the summer of 1988. After this progress will be evaluated to determine the merits of further investment of resources.

## 25. SEARS, M.K., PITTS, M. and R.R. McGRAW - Threshold for potato leafhoppers on potatoes in Ontario.

### a. THE EFFECT OF POTATO LEAFHOPPER ON THE GROWTH AND YIELD OF POTATOES

The potato leafhopper is an important pest of potatoes in Southern Ontario. It does not overwinter in Canada, however, but disperses north from the Gulf Coast each spring. Damage to potato plants is caused by the leafhopper extracting sap from and destroying the phloem tissue. This results in a disruption in the translocation of photosynthates to the developing tubers.

Because of the indirect nature of feeding by the insect, the exact relationship between leafhopper numbers and changes in growth and yield of potatoes is not known. As well, there has been some suggestion that potatoes are more or less affected by leafhopper infestations depending on the growth stage of the plants.

In experiments conducted at Cambridge Research Station both in 1986 and 1987, potato plots which were infested during various growth periods with potato leafhoppers resulted in tuber yield losses of up to 35% over sprayed check plots. The tuber initiation (flowering) stage of the potatoes was found to be the most sensitive to leafhoppers while the tuber bulking stage was unaffected by leafhopper feeding in terms of photosynethic rate and yield.

### b. IMPACT OF POTATO LEAFHOPPERS ON POTATOES IN SOUTHERN ONTARIO

Yield loss due to infestations of potato leafhoppers on potatoes was evaluated in three locations in 1986 and 1987. In each season plots were established at the Cambridge Research Station at Guelph, the Agriculture Canada Research Station at Harrow and at the Horticulture Research Institute at Simcoe. Plots (4 rows x 15 m) of "Superior" potatoes were planted and 5 treatments represented levels of control based on weekly monitoring of the leafhopper density in each plot. Thresholds of 100, 50, 25, and 10 leafhoppers per 20 sweep samples and an untreated control were established and the plots sprayed with Monitor or Decis when the populations exceeded these levels. Yields of the plots were assessed by harvesting the centre two rows of each plot.

Data for 1986 was presented previously. At each location, differences in yield were due to the levels of leafhoppers maintained in each plot (Fig. 1). Yields varied among the three locations so the data were not combined for analysis. At Cambridge and Harrow, where significant yield reductions resulted from leafhopper feeding, a 10% loss resulted from mean leafhopper populations of 12 and 23 leafhoppers per 20 sweep samples, respectively. These densities of leafhoppers were maintained with 3 and 4 insecticide applications at each location, respectively.

In 1987, differences in yield were again correlated with different levels of leafhoppers (Fig. 2). Yields varied sufficiently among locations so that data were analyzed separately. Yield response to leafhopper infestation was similar at Cambridge and Harrow. A 10% loss resulted from infestations during the season of 20 and 27 leafhoppers per 20 seep samples, respectively. At Simcoe, yields were ca. twice that at the other locations. Yield response was significant, but only at the highest level of infestation (untreated control). A 10% loss in yield at Simcoe resulted from an average leafhopper density of 40 per 20 sweep sample. Three applications of insecticides were required at each location to maintain leafhopper populations at levels which did not result in yield loss.

Yield of potatoes is influenced by many stress factors. Feeding by potato leafhoppers adds to this stress and appears to cause yield loss when their populations exceed 15 to 20 leafhoppers per 20 sweep sample over the season. Moisture stress and other pests likely obscure this relationship and more information must be obtained before a reliable estimate of the impact of leafhopper infestations can be established.

Fig. 1

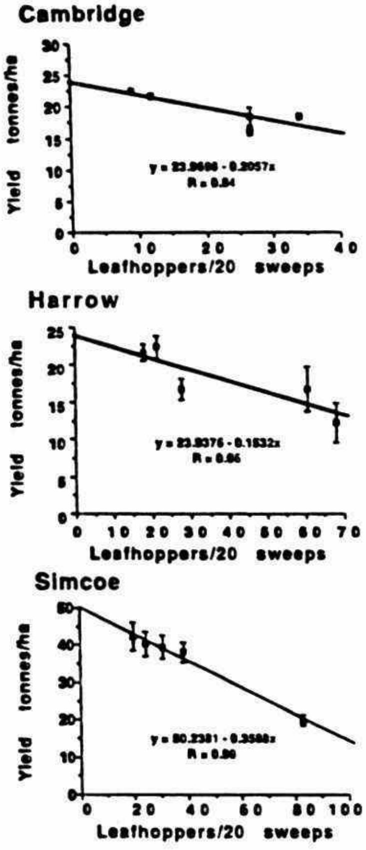
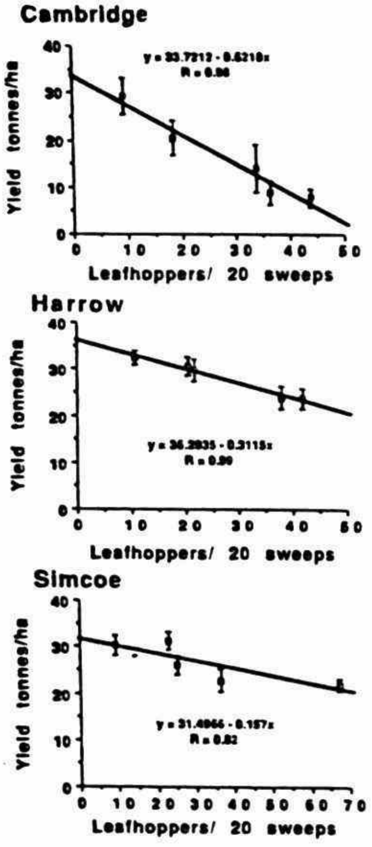


Fig. 2



### 26. SMITH, S.M., - A barrier-trapping technique for the control of Glischrochilus quadrisignatus (Coleoptera: Nitidulidae) and assessment of the dispersal behaviour of the beetle between raspberry, corn and tomato fields.

The Problem

The sap or picnic beetle, Glischrochilus quadrisignatus (Coleoptera: Nitidulidae) (sometimes known as a "beer bug") can be a serious pest of tomatoes, corn, melon and raspberry crops in Ontario. In the Waterloo region of the Province, this insect has become of increasing importance during the past decade, but has not received much recent attention from applied entomologists or crop-protection specialists. Not only is the insect a pest of high-value crops, it may serve as a vector of fungal diseases. Moreover, the habit of the adult of attacking the crop near the time of ripening make pesticidal approaches to its control unacceptable. Moreover, the adult insects are cryptic and would be difficult to "hit" with pesticides in any event.

These beetles respond to many baits and the literature has several reports of them being attracted to fermenting vegetable matter, ripening fruit, or "yeasty" substances such as ale or sparkling wines such as champagne.

Given the difficulty of pesticidal control, ot is desirable to develop other approaches.

The objectives of the project are:

1. To develop an efficient, inexpensive, long-lasting trap for adult sap beetles.
2. To find suitable chemical attractants that could be used in a trap.
3. To demonstrate that a trapping strategy can be effective in reducing numbers of beetles on chosen crops.

All traps were baited with 30 g of banana. They were set out in a 6 x 6 Latin-square design in a raspberry field at New Hamburg, Ontario. Within a row, traps were 24 m apart; columns were 6 or 12 m apart, the distances varying to ensure that trap columns had intervening rows of raspberry canes.

Captures varied markedly across both trap designs and replicates. The variance across replicates is due, in part, to seasonal trends in beetle-population sizes. Two trap designs, the newspaper trap (that had been highly successful in earlier work in Quebec) and the Pherocon trap, were markedly inferior. The other four traps were highly successful in capturing large numbers of beetles. The relative ranking of the traps depended to some extent on the replicate, but the flower-pot trap was

Table 1. Trap Descriptions

The traps tested were both commercially available and home-made devices:

1. Ellisco trap

   This is a commercially available trap for Japanese beetles (Trece Inc., Salinas, CA). For use in the present project, the trap was similar in design to the trap used by Alm et al. (1985) except that the top portion of these traps is now made of plastic and the trap does not have a bait receptacle. For our experiments, the bait was placed directly in the Mason-jar capture unit.

2. Pan trap

   This is a home-made design, slightly modified from a design published by Attwater (1982). It consisted of two round, aluminum pie pans (diameter 21.5 cm), spray-painted flat white and clamped together with 4 heavy-duty binder clips to form a cavity. Eight triangular slits around the edge and one circular hole in the centre were cut in the top pan. The metal in the centre of each triangle was bent in to permit entry of the beetles.

3. Flower pot

   This is a modification of Luckmann's (1963) design. It consisted of a 6-L, black, coarse-plastic flower pot (the type that is so commonly available at nurseries in Ontario in the spring) with a white funnel (19-cm diameter), covering the mouth. A hole (1.0 x 0.5 cm) was drilled 2.5 cm from the bottom of the pot, covered with fine nylon mesh to prevent overflow.

4. Multipher I trap

   This is the commercially available bio-control trap (Services Bio-Contrôle, Ste. Foy, Quèbec).

5. Pherocon trap

   These are the commercially available traps from Zoecon Industries (Port Perry, Ontario).

6. Newspaper Trap

   This is a home-made trap consisting of a wet paper towel containing the bait, rolled up inside a section of newspaper, secured with masking tape.

either the best or the second best trap in terms of absolute numbers caught. Given that in most trials, the four traps were statistically indistinguishable, a choice among the traps can be based on economics, durability, and ease of construction and use. Clearly the flower-pot design is the design of choice for further studies and for control.

Chemical Attractants

We tested 4 synthetic chemicals for attractancy in the field to adult sap beetles: N-butyl acetate, propyl propionate, isobutyl acetate and 2, 3-butanedione. Banana and water were used as controls. In all of our replicates, n-butyl acetate and propyl propionate were the most attractive compounds. However, these studies were conducted towards the end of the field season when beetle numbers were declining. As a result, we were unable to statistically distinguish between these two attractants, even though the rank order was consistent across replications.

Dispersal

A mass-trapping effort was conducted in the Ancaster region (on a farm with both raspberry and melon crops) in late August. Ellisco traps were baited with banana. Trapped beetles were removed from the traps after 48 hours, counted, and stored for an additional day for purposes of marking.

Beetles were marked with fluorescent powder and released into the raspberry field. Beetles were re-trapped from the field using arrays of banana-baited Ellisco traps placed in concentric circles around the point of release. The trap arrays covered an area of about 1600 $m^2$. Data is being tabulated.

### 27. SOUSA MACHADO, V. and ALI, A. - Alternative herbicides for allidochlor in onions.

Field evaluation of metolachlor applied preemergence at 1.92 kg ai/ha followed by CIPC at 4.5 kg ai/ha resulted in good weed control, up to the 3 fully developed leaf stage of onion. Higher rates of metolachlor at 2.65 kg ai/ha effectively controlled weeds, with no phytotoxicity evident on the onion plants. Residue analysis at harvest, indicated non-detectable levels of <0.02 ug/g in the onions, with either of the low or high treatments of metolachlor. However, metolachlor residues were detected in the soil samples from the treated field plots at harvest, ranging from 0.5 to 6.7 ug/g. Acetochlor at 0.5 kg ai/ha preemergence or cyanazine at 1.75 kg ai/ha early loop also provided good weed control, but the cyanazine treatment proved phytotoxic to the onion seedlings. Cynmethylin applied preemergence also resulted in crop phytotoxicity.

At the postemergence level when the onions had reached the 2 to 3 fully developed leaf stage, split applications of oxadiazon consisting of three sprays of 0.4 kg ai/ha each at two week intervals, resulted in very good weed control with no onion phytotoxicity. Applications of lactofen, bentazon or bromoxynil at the levels tested, caused some crop phytotoxicity.

Metolachlor and CIPC preemergence followed by oxyfluorfen or oxadiazon postemergence, may prove to be good potential substitute herbicides for allidochlor and do merit consideration for the minor use registration process.

### 28. STEPHENSON, G.R., BOWHEY, C.S. and EKLER, Z. - Persistence, mobility and activity of sulfonyl urea herbicides in an Ontario soil.

A field study was initiated to examine the chemical and biological persistence of chlorsulfuron in an Ontario agricultural soil. Analysis of samples by gas liquid chromatography is under way to examine total chlorsulfuron persistence as well as leaching to depths of 0-10 cm, 10-20 cm and 20-30 cm in the soil. At the end of the two year study, companion samples will be bioassayed with lentils to permit a comparison of chemical persistence with disappearance of biological activity in the soil.

Bioassay studies with corn, wheat, sunflower, peas, lentils, faba beans, and alfalfa indicated that lentils and alfalfa were the most sensitive bioassay plants for chlorsulfuron. Lentils were also the most sensitive bioassay plant for picloram, a more established and more widely used herbicide which was included in the study for comparison purposes. Concentrations of chlorsulfuron as low as 0.1 ppb (ug/kg) in soil still caused visual and quantifiable injury to lentils and alfalfa. The "no-effect level" for chlorsulfuron with the most sensitive plant species in our study was 0.01 ppb (0.01 ug/kg soil). At present the detection limit for chlorsulfuron in soil with gas liquid chromatography techniques is approximately 0.2 ppb (0.2 ug/kg). Thus, there is definitely the chance for biological activity at levels which cannot yet be detected chemically.

In comparative soil mobility studies with soil thin layer chromatography, three sulfonyl urea herbicides: chlorsulfuron, sulfometuron methyl and metsulfuron methyl were moderately to highly mobile in Guelph loam soil. Mobility was greater when the pH of the soil solution was increased but co-treatment with increasing levels of simazine did not alter mobility.

### 29. STOKES, P.M. and WHELPDALE, D. - Pesticide residues in lichens from the northern Great Lakes basin: an assessment of a biomonitor.

Cryptogams have been used extensively in the past as biomonitors for inorganic pollutants including sulphur and metals, most frequently in the context of local or point sources of air-borne pollutants. We have attempted to establish the levels of organic air-borne pollutants, including organochlorine pesticides, in lichens from a number of remote areas in Ontario. Our goal is to determine the feasibility of using lichens to detect long-range transport and subsequent deposition of air-borne contaminants. We have as our objectives to determine the levels of pesticides in lichens in Canada, compared with those in other parts of the world, and to assess the within-site and between-site variability *Cladina rangiferina*. Furthermore, by looking at the ratios of the original and the transformed components of certain pesticides, we hoped to be able to determine whether the sources were old or recent. In 1985, we sampled from 10 sites across Eastern Canada, and found low but measurable residues of several persistent pesticides in all sites. In 1986 and 1987, we have sampled 45 sites in the Upper Great Lakes basin. In general, levels of pesticides in Canadian lichens are quite low compared with those in mainland Europe, Scandinavia and the United States. In addition, a comparison of the relative amounts of the different forms of DDT and BCH suggests aged residues rather than recent sources of these components. The 1987 study will also attempt to relate the accumulated organics in the lichen with concentrations in precipitation, in order to determine the ability of the lichen to reflect real differences among areas or regions.

Work Completed

Experimental design.

Site selection was based on meteorological regime, pollutant deposition fields, land use and distribution of vegetation. Sample collection was based on the location of ombrotrophic bogs, accessibility for field workers, and procedure were based on the need to recover recent growth, avoidance of contamination or sample degradation during collection shipping and storage.

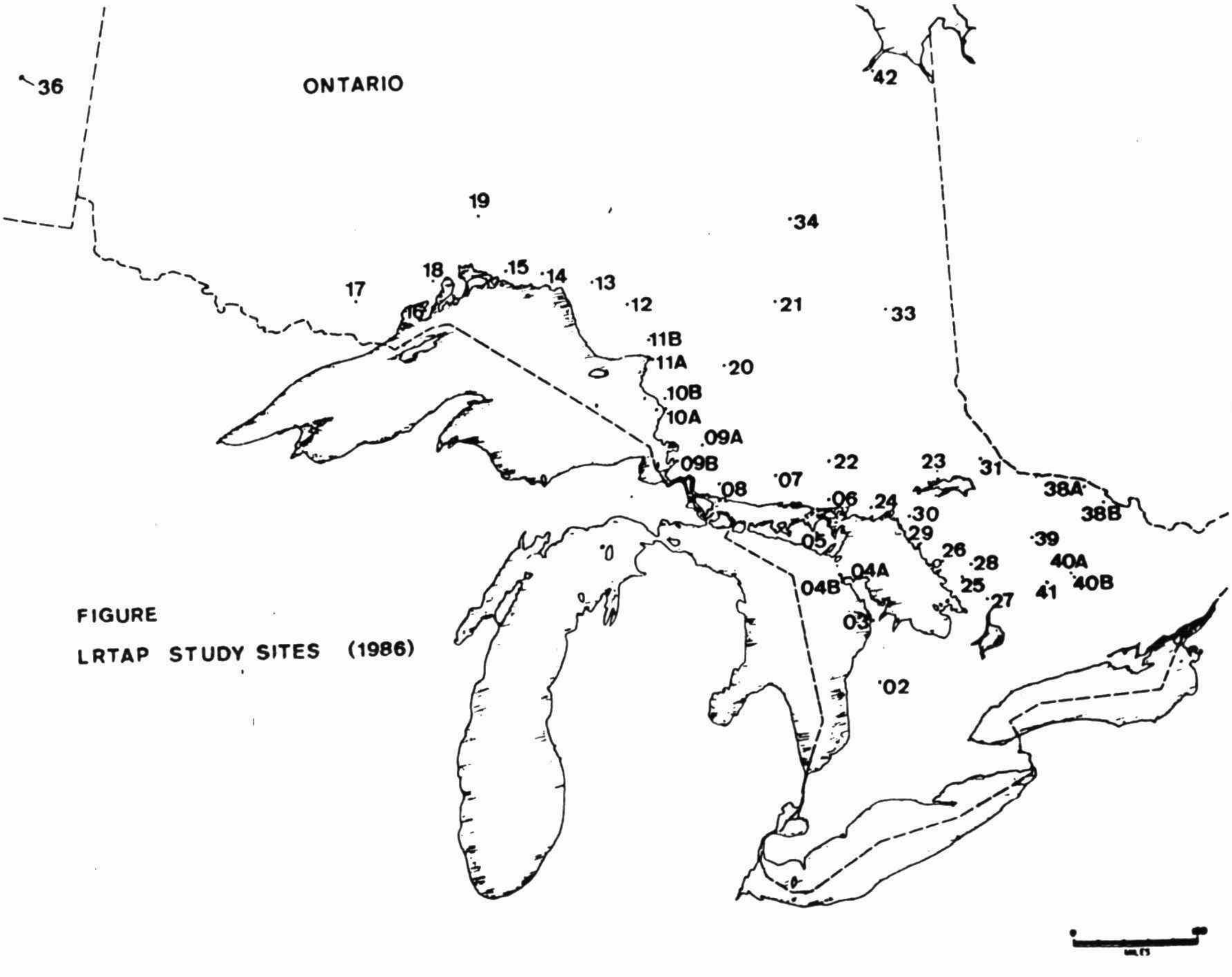


Figure 1. Map of Sites for 1986 Collections

Field collections in 1986 were made from 47 field sites. In 1987, some sites were dropped while more intensive sampling was carried out within other sites (Fig.1). This was to determine possible sources of variation or error as well as to ensure that lichens were collected close to sites where organics would be determined in precipitation. In all instances, triplicate samples were collected, and at most sites, Sphagnum moss was also collected and is in storage pending the need to compare elements or compounds in different species of cryptogams from the same sites.

Plant material was prepared in the laboratory for analysis. Species identification was confirmed and recent growth (the terminal 1 cm, since lichens cannot be aged accurately) was separated. All the lichens and most of the moss from 1986 have been analyzed for metals, organochlorines and PCB's, and one third of the samples have been analyzed for PAH's.

## Results

In most instances the concentrations of pesticides from all of our Upper Great Lakes sites were lower than those in lichens from other parts of the world, with the exception of Antarctica. At present stage of analysis of the data, concentrations of most pesticides are fairly uniform across the region, suggesting an absence of a local source or sources and an influence of distant sources.

Triplicate samples revealed a relatively low coefficient of variation within sites (generally less than 20%) for organics, although some metals were much more variable.

There is a suggestion for some species, e.g. dieldrin, total-DDT, total chlordane and toxaphene, of higher concentrations in the southern portion of the Upper Great Lakes basin, presumably a reflection of atmospheric transport and deposition from more heavily-polluted areas.

### 30. **SURGEONER, G.A., GLOFCHESKIE, B.D. and WHISTLECRAFT, J.- Management of house flies by sanitation - Impact on resistance.**

In 1987, weekly manure management programs were maintained on a dairy farm with a previous history of severe resistance by the house fly to insecticides. The management program involved three hours of labour per week at a cost of $10.00 to $15.00 per week. The producer was allowed to spray on a per need basis. In 1987, a single pyrethrum 1% AI spray was used. Prior to a sanitation program, two to three sprays per week of organophosphorous, carbamate or pyrethroid insecticides had been used throughout the summer months.

Resistance ratios of house flies have shown significant declines. Pyrethroids (permethrin) 89% reduction, carbamates (carbofuran) 54% reduction, and organophosphorous insecticides (dichlorvos) 57% reduction over three years. These results are similar to a laboratory strain maintained for 37 generations. It is expected that resistance would quickly return if insecticides were again used. Currently, susceptible WHO flies (ca. 1,000/2 weeks) are being released into the premises. Mark-recapture experiments indicate that a ratio of 4:1 to 9:1 susceptible to resistant flies are in the barn. The impact of these releases on resistance levels will be assessed in May 1988. Recapture experiments indicate that five sticky monitors remove 10-24% of the flies per week from the barn.

Non-chemical research on house fly control initiated by OPAC is now being funded by the Ontario Egg Marketing Board. Studies have shown that ventilation in deep pit poultry operations has resulted in significant declines in house fly numbers without the use of insecticides.

### 31. SUTTON, J.C. - Biological control of strawberry and raspberry diseases.

The microflora of strawberry foliage were monitored from August 1986 to July 1987 to identify organisms of potential value in the biocontrol of grey mold, leaf spot and other foliar and fruit diseases. Leaves at the bud stage were tagged on 1 August, 12 September, 7 November and 17 April. The tagged leaves were sampled immediately and at 7-day intervals (14 days when under snow) until they died 3 to 9 months later. Microorganisms were recovered by A. incubating unwashed leaf pieces in humid chambers; B. washing leaf pieces and plating the wash water; and C. plating pieces of the washed leaves onto agar media. Fungi common at all developmental stages of the leaves and at all times of the year included *Gliocladium* sp., *Verticillium*, *Cladosporium* spp., *Alternaria alternata* and white yeasts. Pink yeasts (*Sporobolomyces* etc.), *Trichothecium* and *Epicoccum* also were common at most times of the year. However, white yeasts were more numerous than pink yeasts. A range of bacteria, including *Pseudomonas*, also were recovered. Several of the various kinds of microflora were present on young leaves folded tightly in the bud.

*Botrytis cinerea*, was common in leaves of all developmental stages, including the bud. Incidence of the pathogen was lower in leaves tagged on 1 August than at other tagging times.

Fifty-four various yeasts and bacteria isolated from strawberry leaves were tested for biocontrol activity against *B. cinerea*. For the tests, each isolate was applied to strawberry leaf discs which were incubated in a humid atmosphere for 2 days, then challenge-inoculated with *B. cinerea*. Biosuppression was assessed by estimating densities of *B. cinerea* conidiophores on the discs after three further weeks of incubation. Cluster analysis placed the potential biocontrol agents into four groups in which sporulation was 80-93% (same as check), 52-79%, 24-48%, and 2-

25%. The best three isolates, two white yeasts and one bacterium, were tested for biocontrol in the field. The isolates were tested on the flowers in the spring of 1987, and on the leaves beginning September 1987. The latter test will be completed in July 1988.

In the tests of biocontrol of B. cinerea on the flowers and fruits, the two yeast isolates and the bacterium were sprayed onto plots of strawberries on 26 May and 2, 10, 18, and 26 June. Each isolate was applied in water or a nutrient suspension of sucrose (2%) and yeast extract (0.01%). Flower clusters were tagged and sampled at intervals. The nutrients alone suppressed grey mold by 50%. One of the yeasts and the bacterium each suppressed disease by 83% when applied in water. Additional nutrients did not increase disease suppression.

Fields of red raspberries were sampled in June and July 1987 to identify sources of B. cinerea and distribution of the pathogen on the crop. This information was gathered as a basis for developing rational biological control of the pathogen in raspberries. Plant material and soil were collected from several rows in fields at Mapleview Farms, north of Guelph. Sclerotia of B. cinerea were quantified in the soil samples. Living and dead parts of raspberry plants were incubated in moist chambers, then examined for B. cinerea. No sclerotia were found in soil samples and only one was found on an old cane (but numerous sclerotia were noted on old canes in some other plantings which had not been sprayed with fungicides). Incidences of conidiophores and conidia of B. cinerea were high (48-71%) on dead leaves of the current year and very high (92%) on overwintered inflorescences. Incidence on flower parts and receptacles of aborted fruits also was high (77%). Incidences on other living parts were : green leaves (0%), red berries (56%), receptacles (50%), stamens (11%), and anthers (28%). We conclude that key sources of initial inoculum were old inflorescences and (in some plantings) sclerotia on old canes. Biological control may be more easily attained in terms of protecting the flowers and fruits than in terms of suppressing inoculum production in the various sources.

# APPENDIX IV : PUBLICATIONS RELATING TO THE ONTARIO PESTICIDES ADVISORY COMMITTEE RESEARCH PROGRAM, 1987-88

## A) RESEARCH

**BOLAND, G.J.** and J.E. Hunter. 1988.
Influence of *Alternaria alternata* and *Cladosporium cladosporiodes* on white mold of bean caused by *Sclerotinia clerotiorum*. Can. J. Plant Pathol. 10: 172-177.

**BURPEE**, L.L., L.M. KAYE, L.G. GOULTY, and M.B. LAWTON. 1987.
Suppression of gray snow mold on creeping bentgrass by an isolate of *Typhula phacorrhiza*. Plant Disease.71(1): 97-100.

LAWTON, M.B., **L.L. BURPEE**, and L.G. GOULTY. 1986.
Factors affecting the efficacy of a biofungicide for control of grey snow mould on turfgrass. Proc. 1986 British Crop Protection Conference.

McAUSLANE, H.J., **C.R. ELLIS**, and P.E.A. TEAL. 1986.
Chemical attractants for monitoring for adult northern and western corn rootworms (Coleoptera: Chrysomelidae) in Ontario. Proceedings of the Entomological Society of Ontario 117: 49-57.

**FRANKENHUZEN, K. van.** 1987.
Effect of wet foliage on efficacy of *Bacillus thurigiensis* spray against the spruce budworm, *Choristoneura fumiferana* Clem. (Lepidoptera: Tortricidae). The Canadian Entomologist 119: 955-956.

**HARRIS, C.R.**, R.A. CHAPMAN, J.H. TOLMAN, P. MOY, K. HENNING, and CAROL HARRIS. 1988.
A Comparison of the persistence in a clay loam of single and repeated annual applications of seven granular insecticides used for corn rootworm control. J. Environ. Sci. Health, B23(1): 1-32.

TU, C.M. and **C.R.HARRIS**. 1987.
A description of the development and pathogenicity of *Entomopthora muscae* (Cohn) in the onion maggot, *Delia antiqua* (Meigen). Agriculture, Ecosystems and Environment 20: 143-146.

DAY,K. and **N.K. KAUSHIK**. 1987.
The adsorption of fenvalerate to laboratory glassware and the alga Chlamydomonas reinhardii and its effect on uptake of the pesticide by Daphnia galeata mendotae. Aquatic Toxicology 10: 131-142.

DAY, K.E., **N.K. KAUSHIK**, and K.R.SOLOMON. 1987.
Impact of fenvalerate on enclosed freshwater planktonic communities and on in situ rates of filtration of zooplankton. Can. J. Fish. Aquat. Sci. 44: 1714-1728.

DAY, K.E. 1986.
The acute, chronic and sublethal effects of the synthetic pyrethroid, fenvalerate, on zooplankton in the laboroatory and the field. Ph.D. Thesis, University of Guelph, Guelph, Ontario. 200 pp.

SANDERS, C.J. 1987.
Controlled release sex phermone lures for monitoring spruce budworm populations. The Canadian Entomologist 119(4): 305-313.

SANDERS, C.J. 1988.
Monitoring spruce budworm population density with sex phermone traps. The Canadian Entomologist 120(1): 175-183.

SANDERS, C.J. 1986.
Accumulated dead insects and killing agents reduce catches of spruce budworm (Lepidoptera: Tortricidae) male moths in sex phermone traps. J. Econ. Entomol. 79: 1351-1353.

**SUTTON**, J.C., T.W.D. JAMES, and A. DALE. 1988.
Harvesting and bedding practices in relation to grey mould of strawberries. Ann. Appl. Biol. 113: 167-175.

BRAUN, P.G. and **J.C. SUTTON**. 1988.
Infection cycles and population dynamics of Botrytis cinerea in strawberry leaves. Canadian Journal of Plant Pathology 10: 133-141.

## B) MISCELLANEOUS

**BARBER, K.** 1988.
Development of a monitoring protocol for using the fecundity of Polygonatum pubescens as an indicator of impacts of forest sprays on bumblebees. Forest Pest Management Institute, Canadian Forestry Service File Report No. 92, March 1988.

**BUTTLE, J.M.** 1988.
The role of sediment in metolachlor transport from agricultural fields. Presented to Third General Assembly of the International Association of Scientific Hydrology, May 1989.

**SURGEONER, G.A.** 1987.
Controlling flies the old fashioned way. Ont Milk Prod. July. pp 16-19.

MARTIN, A.V.M., **P.M. STOKES**, and D.M. WHELPDALE. 1986.
Organic contaminants in the lichen Cladina rangiferina at nine rural and remote sites in Eastern Canada: How does Kejimkujik measure up? Presented at the Kejimkujik LRTAP Studies Workshop, Kejimkujik National Park, Oct 8-9, 1986.

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Pesticide research projects :
funded by the ministry of the
environment through the
Ontario pesticides advisory
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